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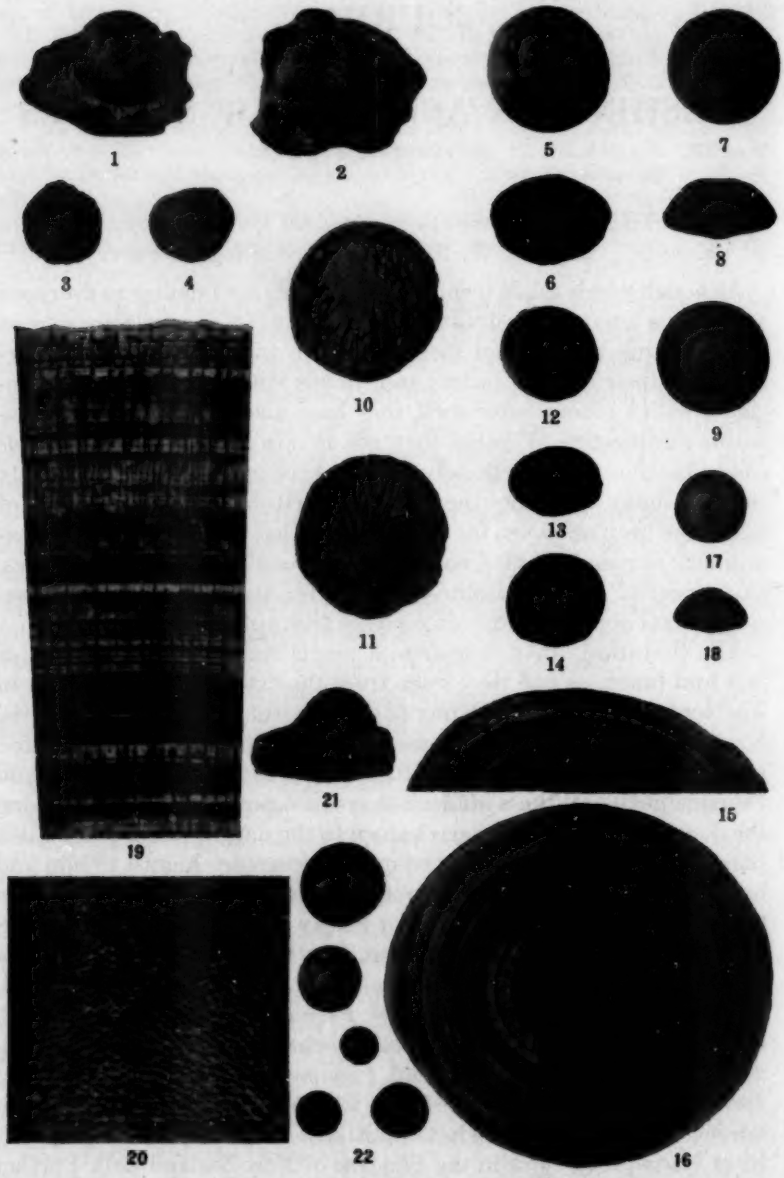
PALEONTOLOGY.—*Fossil pearls from the Colorado group of western Kansas.*[1] ROLAND W. BROWN, U. S. Geological Survey.

Although pearls taken from living mollusks are familiar to everyone as lustrous ornaments, often of great beauty, fossil pearls are seldom seen. As a rule they are not spectacular, for, with few exceptions, they have lost their original luster; and, unless still embedded in or associated with an identifiable shell, they have also lost some of their scientific significance. Whether they are as rare as the 45 or 50 records would indicate is not definitely certain, because it is altogether likely that by many collectors they may hitherto have been unsought or may have been mistaken for other objects that simulate them, such as ordinary rounded pebbles, concretions formed by inorganic processes, cave "pearls," oolites, pisolites, otoliths, fish teeth like those of *Sphaerodus*, algal nodules, and even seeds or fruits of plants.

The literature about ornamental pearls runs the whole gamut of fact and fancy, as one may learn from the extensive bibliography in *The book of the pearl* by Kunz and Stevenson (18). Of fossil pearls, however, the literature embraces only about 30 titles. These are cited in part in the recent papers by Russell (24), Berry (2), Zilch (33), and Frenguelli (9). All these students have also published tables showing the distribution of fossil pearls known to the date of publication. Zilch (33), in particular, has reviewed every occurrence known to him and has made two changes that should be noted by those who compare these tables, namely, *Perna oblonga* Seeley is *P. seeleyi* Zilch, and *Perna sandbergeri*, cited erroneously at first by Zilch (32), is *P. oblonga* Röhmer and Büchner (33). In the latest table, that by Frenguelli, *Perna oblonga* should read *P. seeleyi; Perna sandbergeri* should read *P. oblonga* and the occurrence 5 should be changed from Pliocene to Oligocene; *Nautilus* sp. should read *Pleuronautilus pseudoplanilaterus;* also the occurrence cited as 30 in the Eocene should be changed to Oligocene. All the tables cited have omitted J. Marwick's record of pearls from *Melina zealandica* in the Pliocene of New Zealand (20). Further

[1] Published by permission of the Director, Geological Survey, U. S. Department of the Interior. Received April 29, 1940.



Figs. 1–22.—(See opposite page for explanation.)

records not appearing in previous tables are those by Dorn (7) and Kutassy (19). Here too may be added a note that Dr. S. F. Blake, of the U. S. Bureau of Plant Industry, has found subsequent to Berry's record (2) a large blister pearl also in a *Panopea americana* shell from the Miocene at Jones Wharf, Md. Blake's pearl is slightly larger than Berry's but has the same outline and occurs in exactly the same position near the hinge line. The exterior of the shell does not now show evidence of having been perforated, but irregularities in the amount and contour of shell substance indicate that some pathologic condition prevailed. The instances to be recorded here are worthy of being added to the list of occurrences of fossil pearls, because the pearls are not only firm, unusually large, well formed, and characteristic, but the records are from strata that, although carrying marine faunas chiefly of Foraminifera and Mollusca, have not yet been cited as yielding pearls.

Five of the new specimens (Figs. 1, 3, 4, 5, 12) were collected by George F. Sternberg, of the Fort Hays Kansas State College, at Hays, Kans., from scattered outcrops of the Niobrara formation (Upper Cretaceous) along the Smoky Hill River valley west and southwest of Hays and extending into Gove and Logan Counties toward the head of that valley. Several of these specimens were taken from remains of *Inoceramus*, but a few were found free. Two specimens (Figs. 7, 10) were collected by A. H. Schutte, of Ellis, Kans., from the Benton shale, which underlies the Niobrara limestone, along a tributary of Smoky Hill River, 16 miles south of Hays. These 7 specimens, together with 36 more collected by a friend of Mr. Sternberg from the Benton shale 18 miles east of Hays, were sent to the writer by Mr. Sternberg for confirmation of the tentative identification as pearls.

All the Niobrara pearls are now lusterless and are dull, yellowish gray to dark gray in color. Four are of discoid or oblate spheroid form, the largest (Figs. 5, 6) having a long diameter of 2 cm and a

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Figs. 1–6, 12–16, 19, 20.—Fossil pearls from the Niobrara limestone. Figs. 1, 2.—Different views showing same pearl partially embedded in the prismatic layer of an *Inoceramus* shell. Fig. 6.—Side view of 5. Fig. 13.—Side view of 12, showing equatorial line where cut was made for section 14. Fig. 15.—Section at right angles to the long diameter showing irregularities in deposition of the laminae. The dark spots are limonite. ×4. Fig. 16.—Same as 14, ×4. Fig. 19.—A sector of 14, showing radial prismatic calcite, ×40. Fig. 20.—Polygonal surface pattern of 5. ×16. Figs. 7–11, 21, 22.—Fossil pearls from the Benton shale. Figs. 7–9.—Top, side, and bottom views of a hemispheric pearl. Figs. 10, 11.—Top and bottom views of a baroque. Figs. 17, 18.—Bottom and side views of a modern hemispheric pearl from the common clam, *Venus mercenaria*, for comparison with 8 and 9. Fig. 21.—A hemispheric pearl resting on the prismatic layer of an *Inoceramus* shell. Fig. 22.—Group of spherical pearls. All figures natural size except as indicated.

short diameter of 1.3 cm. The smaller specimens (Figs. 3, 4) are somewhat irregular and appear to have suffered slight fracturing and distortion by mechanical causes probably subsequent to entombment in the Niobrara sediments. Portions of the smooth outer laminae of some of the pearls have been spalled off. This outer surface, where well preserved, is seen under a 14-power hand lens to be a pattern of minute, closely packed polygons (Fig. 20), each convexly domed outward. These polygons represent the slightly eroded ends of radial prisms. The smooth surface of the prismatic layer exposed on the interior of an *Inoceramus* shell displays the same pattern.

Figs. 1 and 2 illustrate an almost spherical specimen, similar in color and texture to the others but partially embedded in a piece of the prismatic portion of the host *Inoceramus* shell. Nothing apparently now intervenes between the pearl and the shell, and none of the nacre of the shell remains, but whether this means that the growth of the prismatic layer was gradually enveloping the pearl is a matter of conjecture, though parallels to this condition are not rare in modern mollusks. The writer has been unwilling to risk destruction of the pearl by attempting to detach it from the shell merely to satisfy curiosity on this point.

One specimen (Figs. 12–16) was cut in half through the equator by using a thin copper wire and carborundum powder. The sections reveal numerous light and dark, concentric, closely-spaced rings or laminae around a small, indefinite, rusty-stained nucleus. Darker parts of some rings are transitional circumferentially into lighter portions of the same rings. Under the microscope the rings show some slight variations in smoothness of curvature and in width both in themselves and as compared with one another (Fig. 19). They are composed for the most part of large, radially disposed crystals of calcite. No conchiolin appears to be present now. The section does not display a black cross under crossed nicols, and in this respect is similar to the prismatic portion of Russell's second pearl (24, p. 422). Narrow radial zones of distortion along which secondary calcite has been sporadically deposited may be seen in the right half of Fig. 16. Fig. 15 is a section cut through the short diameter at right angles to the long diameter. It differs from the previous section chiefly in showing greater irregularity in deposition of the concentric laminae. The dark spots are flecks of secondary limonite, probably after pyrite. These sections compare well with those reproduced by Russell (24, figs. 4–7), Newton (22, pl. 5, figs. 3–6), Kunz and Stevenson (18, plate facing p. 53), and others.

It has already been intimated that the Niobrara pearls were produced by a species of *Inoceramus*. The large size of the pearls predicates a large mollusk as host, and this suggests that *Inoceramus* [*Haploscapha*] *grandis* may have been the species, but certainty concerning this can not be established until a pearl is found in a shell or portion of shell which can be specifically identified.

The Benton pearls are of various forms: spherical (Fig. 22), oblate, hemispheric (Figs. 7, 21), oblong, and irregular (Fig. 10). These pearls are, in general, darker in color than the Niobrara specimens. The largest is an irregularly rounded baroque, 3.5 cm in diameter, with a corrugated surface. The surfaces of these pearls display the distinctive polygonal pattern noted in the Niobrara pearls (Fig. 20), and there is no doubt that the Benton pearls were also produced by one or several large species of *Inoceramus*, for a number of specimens are still attached to portions of shell showing the characteristic hinge line.

Figs. 7, 8, and 9 represent a specimen, hemispherical in general form, its top (Fig. 7) slightly flattened with a depression in the center. The under side (Fig. 9) displays a series of concentric growth rings, but at the outer edge can be seen the now ragged margin of the smooth coating of the upper surface lapping over on the under surface. This condition can be matched by the structures observable on the under sides of modern hemispheric pearls (Figs. 17, 18) from the common clam, *Venus mercenaria*. The dimple on the top side also finds its counterpart in some modern pearls. The development of hemispheric pearls is explained by Kunz and Stevenson (18, p. 57) as follows:

> When a growing pearl is very near to the nacreous lining of the shell, the pressure between the two hard substances results in a rupture of the pearl-forming sac and the epithelial layer of the shell, and the pearl comes in actual contact with the nacre. The pearl gradually becomes attached to the shell, and the under portion is prevented from growing further; the upper or exposed surface receives other layers, resulting in the formation of a *bouton*.

Figs. 10 and 11 represent the top and under sides of an irregular, flattened pearl. In structure and appearance this specimen seems unrelated to those already described. On the under side, however, eccentric lines of growth around a distorted nucleus can be detected, and the smooth patch on the upper side under a 14-power hand lens displays the same polygonal pattern as the surface of the other pearls. Because this pearl is thin, flat, and irregularly but smoothly lobed or corrugated it would seem to compare best with a modern baroque or perhaps a blister pearl. The latter are said to be formed when foreign

TABLE 1.—DISTRIBUTION OF FOSSIL PEARLS. (Numbers refer to citations. B, N = Benton and Niobrara pearls described in this paper.)

Host shell	Triassic	Jurassic	Cretaceous	Eocene	Oligocene	Miocene	Pliocene	Pleistocene
Ceratites compressus	16							
Exogyra texana			1, 24					
Gryphaea dilatata		14, 21						
Hippurites sp.			17					
Inoceramus expansus			22					
goldfussianus			10					
labiatus			22					
sagensis			27					
subundatus			24					
spp.			14, 21, 22, 31, B, N					
Lima scabra							14	
Megalodus amplus	19							
Melina zealandica							20	
Mytilus edulis								14
trigonus?						9		
Ostrea cymbula				6				
eduliformis		7						
edulis							14	
tenera				14				
ventilabrum					25			
sp.				6, 29, 30				
Panopea americana						2		
Perna heberti					33			
maxillata						12		
oblonga						32, 33		
sandbergeri					32, 33			
seeleyi			22, 26, 33					
Pinna affinis?				13, 24				
Pleuronautilus pseudo-planilaterus	15							
Pteria sp.				24				
Volsella modiolus								23
?					3	4, 33		

bodies such as sand grains become lodged between the mantle and the shell, or when a mollusk attempts to repair injuries to the shell.

Many of the fossil pearls so far reported were derived from species of *Inoceramus* of the Cretaceous period, a circumstance that would seem to label these species as the pearl "oysters" par excellence of that time, 100,000,000 years ago. The only other Cretaceous records are from species of *Perna*, *Exogyra*, and *Hippurites*.

No definite pearls have been recorded from the Paleozoic, but J. Smith[2] reports from the Upper Silurian:

Pearls (?).—In the shale at Sedgley, Woolhope, Dormington, Lincoln Hill, Benthall Edge, and Gleendon Hill, a number of minute spheroidal bodies occurred. Some are silvery white, some yellowish, and others of a dark-brown color when viewed by reflected light. All of them have a peculiar pearly

[2] SMITH, J. *Notes on a collection of bivalved Entomostraca and other Microzoa from the Upper Silurian strata of the Shropshire District.* Geol. Mag. n. ser., dec. 2, 3: 72. 1881.

lustre. One that had been split through the middle shows a concentric laminated structure. On washing some of the rotten limestone from the Much-Wenlock quarries, I found these pearls (?) very abundant.

All the Mesozoic and Cenozoic periods are represented by examples. In Table 1 showing the distribution of fossil pearls as now known the numbers refer to citations which, in several instances, include more than one occurrence.

It will be observed that all the mollusks in the list, with the exception of *Ceratites* and *Pleuronautilus*, are bivalves (pelecypods). Theoretically, however, any mollusk that builds a shell by means of a mantle that, besides depositing the horny periostracum or outer layer and the calcareous prismatic middle layer, also secretes the calcareous nacre or mother-of-pearl of the inner layer, should be able to produce pearls. Today most commercial pearls come from species of bivalves: pearl "oyster" (variously assigned to *Pinctada*, *Meleagrina*, or *Margaritifera*), sea mussel (*Mytilus*), fresh water mussels (*Unio*, *Elliptio*, *Anodonta*, *Dipsas*); but species of many other genera also yield pearls. Among univalves (gastropods or snails) the following are known to produce pearls: common conch (*Strombus gigas*), abalone (*Haliotis*), and chank (*Turbinella*). The pearly nautilus (*Nautilus pompilius*), a cephalopod, sometimes produces pearls of a yellowish color.

The inevitable question always asked concerning pearls is, How do they originate? Considerable investigation has been conducted in attempts to penetrate the mollusks' secret, with the result that some specific conclusions now seem sound. To understand the causes and methods of pearl formation it is necessary first to consider what the end product, a pearl, is. The usual spherical pearl is a calcareous concretion composed of a nucleus and many more or less concentric layers or laminae of minutely platy aragonite (mother-of-pearl, nacre, $CaCO_3$), separated by thin layers of organic conchiolin ($C_{30}H_{48}N_2O_{11}$). Spherical pearls, however, are only one of the many forms pearls may take. These forms depend largely on the position of the pearls in the mollusk, whether attached to the shell or free in the mantle or muscle. Pearls originally free may eventually be buried by enveloping shell growth. The free pearl is formed within a sac lined by epithelium, the layer of the mantle that secretes the different parts of the molluscan shell. The methods by which epithelial sacs are formed and how they enclose instigating nuclei are discussed and illustrated by Dakin (5, pp. 91–116), and Boutan (4, p. 294).

Inasmuch as different areas of the mantle surface deposit different parts of the molluscan shell, how does it happen that epithelium de-

rived from one spot in the epithelium of the mantle and now lining an isolated pearl sac can produce a pearl that duplicates the composition and structure of all the substances of the host shell? Dakin (5, pp. 24, 25) answers:

> If a mollusc shell is broken (or a piece of the shell removed) some distance away from the edge, a most extraordinary thing happens, which is of the greatest importance in regard to theories of pearl formation. The shell is repaired, but the repair substance is not, as was once thought, only nacre. The mantle cells, which normally would be secreting nacre, now secrete at the area of breakage, first periostracum, then prismatic layer, and finally mother-of-pearl. Thus, although certain parts of the mantle surface secrete *normally* certain definite parts of the shell, the cells which secrete the nacre are capable of secreting all the other layers if necessary.

It follows that the segregated epithelium surrounding the nucleus of a pearl may deposit layers of both calcareous and organic substances. Part of the epithelium may even be secreting aragonite, while simultaneously another part is depositing conchiolin. Next to an inciting nucleus, therefore, epithelial cells play the essential role in the process of pearl formation.

The importance of the epithelium was demonstrated by the experiments of Alverdes and also by the practical experience of Mikimoto with culture pearls. In the modern culture pearl industry as practiced by the Japanese, a pellet of nacre is first placed on the epithelium of the mantle of one mollusk. After enclosing the pellet and suturing, this part is excised and transplanted to the mantle of another mollusk, which is then returned to the water. Upon removal, after a period of seven years, about 60 percent of the mollusks yield pearls. Of these, 5 percent are said to be marketable (8, p. 423).

Although the age-long empirical methods of the Chinese in artificially stimulating mollusks to produce pearly growths by introducing foreign objects, such as small images of Buddha, between the shell and mantle, suggest that some natural pearls may originate from the accidental intrusion of grains of sand, particles of mud, fragments of shell, etc., nevertheless evidence is accumulating to the effect that many, and perhaps most, natural pearls have their inception from particles originating within the epithelium of the mantle, or from parasitic larvae of worms that become encysted within the epithelium. In the latter case, if the mollusk is not devoured by that one of its predators which is the next required host in the predestined life cycle of the worm, a death sentence automatically passes upon the larva, and it is forthwith entombed in a pearly mausoleum. To quote Kunz and Stevenson (18, p. 45): "Some truth exists in the statement that the most beautiful pearl is only the brilliant sarcophagus of a

worm." Some of the Benton and Niobrara pearls, therefore, may be mute testimonials to the Cretaceous existence of a cestode or trematode of which we may never know anything more. Some may also indicate shell-boring predators.

The writer is indebted to many of his colleagues for help in this study, but particularly to Dr. W. F. Foshag, curator of mineralogy at the U. S. National Museum. Specimens (Figs. 1, 5, 7, 14, 21, 22) are deposited in the U. S. National Museum.

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PALEONTOLOGY.—*Two new corals from the Avenal formation (Eocene) of California.*[1]

JOHN W. WELLS, Ohio State University.
(Communicated by JOHN B. REESIDE, JR.)

The two new species of solitary corals described below were collected by Dr. Ralph Stewart, of the United States Geological Survey, who kindly turned them over to the writer for description. They are particularly interesting because of their close relationships with Eocene corals of the Gulf Coastal Plain and the Antillean regions.

Family CALAMOPHYLLIIDAE

Genus ANTILLOSERIS Vaughan, 1905

Antilloseris? vaughani, n. sp. Figs. 1, 2

Corallum solitary, turbinate, flaring rapidly from a subcylindrical base. Calice circular, shallow. Corallite wall synapticulothecal, thickened to a septotheca basally, irregularly perforate near calicular margin, nonepithecate, costate. Costae corresponding to all septa, equal, crispate or finely granulose laterally and on margins. Septa very numerous, in six systems, probably with six complete cycles and part of the seventh (about 250 septa in holotype). Septa thin, mostly imperforate and laminar, except those of the first two cycles which are relatively thick and laterally and basally subspinose, with inner ends free and thickened. Synapticulae rare except in mural region. Endotheca and exotheca absent. Columella wholly absent.

Dimensions of holotype.—Diameter of calice, 20 mm; height of corallum, 7 mm; diameter of corallum 7 mm below calice, 7 mm.

Holotype.—U.S.N.M. no. 498697.

Type locality.—U. S. Geological Survey locality 14482; California, Kettleman Plain quadrangle, T. 23 S., R. 17 E., sec. 35, 400 feet south of north boundary and 2,110 feet east of west boundary of section, near Little Tar Spring. Avenal formation, near Domengine horizon.

Remarks.—The agaricid nature of this coral is shown by the thin, slightly and irregularly perforated septa and by the synapticulothecal wall. The absence of any dissepiments, even basally, and of any trace of columella further indicates a generic assignment in or very close to *Antilloseris*, a genus confined to the Eocene and heretofore found only in the Antillean region. In all the described species[2] of *Antilloseris*, however, the corallum is more or less

[1] Received April 10, 1940.

[2] DUNCAN, P. M. Quart. Journ. Geol. Soc. London 29: 558–560, pls. 21, 22. 1873. VAUGHAN, T. W. Bull. Mus. Comp. Zool. 34: 245–246, pl. 40. 1899. In both these papers the species included by Vaughan in *Antilloseris* in 1905 are described as *Turbinoseris*.

compressed and tapers basally to a very small point of attachment, and since the present specimen is not compressed and apparently possessed a broad base of attachment, the reference to this genus is not positive.

Family FUNGIIDAE

Genus DISCOTROCHUS Edwards and Haime, 1848

Discrotrochus californicus, n. sp. Figs. 3–5

Corallum solitary, depressed-cupoloid in shape, with flat, circular base with faint scar of very early fixation. Corallite wall septothecal, thick, solid, horizontal, nonepithecate, costate. Costae corresponding to all septa, alternating regularly in size, obsolescent towards center of base. Those corresponding to septa of lower cycles larger, subacute with a few stout granulations on edges. Septa 36 in number, in six systems, imperforate, highly exsert, outer margins vertical, inner ones gently convex to the circular central fossette, laterally ridged or granulated perpendicularly to margins which are peripherally crossed by transverse denticulations where opposing ridges meet over margins. Septa of the fourth cycle not developed in "dorsal"

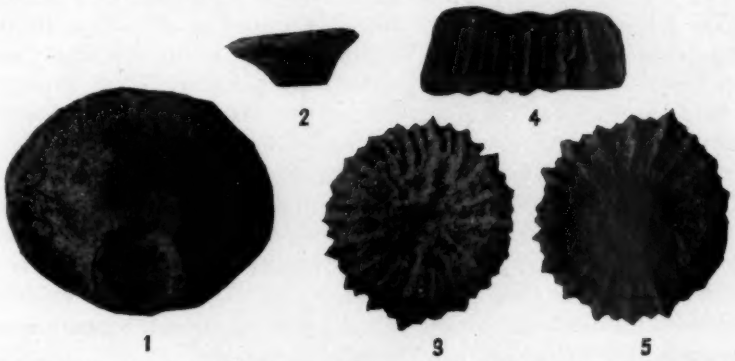

Fig. 1.—*Antilloseris? vaughani*, n. sp., holotype; oblique basal view, showing polished section of base (note absence of columella and dissepiments), ×2. Fig. 2.—Same, lateral view, ×1. Fig. 3.—*Discotrochus californicus*, n. sp., holotype, view of calice, ×5. Fig. 4.—Same, lateral view, ×5. Fig. 5.—Same, basal view, ×5.

half of each of the six systems. Columella trabecular, small, extending upward about half the thickness of the corallum.

Dimensions of holotype.—Diameter of corallum at base, 6 mm; height of corallum, 2.5 mm.

Dimensions of paratypes.—	(1)	(2)	(3)	(4)	(5)
Diameter of corallum.....	6.5	6.2	5.75	5.5	5.5 mm.
Height of corallum.....	3.0	2.0	2.4	2.75	2.5 mm.

Paratype 2 is much worn.

Holotype.—U.S.N.M. no. 498698.

Paratypes.—U.S.N.M. no. 498699, five specimens.

Type locality.—Same as for *Antilloseris? vaughani*.

Paratype locality.—U. S. Geological Survey locality 14482a. Same horizon as type locality but on next ridge to east of type locality.

Remarks.—This species is based upon a holotype (the first collected) and five paratypes from a nearby locality. All are in a fair state of preservation

and show the characters of *Discotrochus*, a genus associated by most authors with the Caryophylliinae. Recent study of the type species, *D. orbignianus* Edwards and Haime,[3] by Dr. T. W. Vaughan and the writer, however, indicates that *Discotrochus* is scarcely distinguishable from the fungid *Cycloseris* except for the rarity of synapticulae, smaller number of septa, and thicker basal wall in *Discotrochus*. The present species is distinguished from the genotype, and only other American species, *D. orbignianus*, of the lower Claibornian (Eocene) of the Gulf Coastal Plain, by the different proportions of the corallum. The ratio of height to diameter of *D. orbignianus* is 1:4, in *D. californicus*, 1:2.5. The latter is therefore relatively much higher than *D. orbignianus*. Further, *D. orbignianus* usually possesses four complete cycles of septa, whereas all the specimens of *D. californicus* examined show the fourth cycle only half developed in each of the six systems.

PALEONTOLOGY.—*A new* Gisortia.[1]

WILLIAM M. INGRAM, Cornell University. (Communicated by JULIA A. GARDNER.)

The *Gisortia* described here, from the Capay stage, Llajas formation, lower zone, Simi Valley, Ventura County, Calif., is the only species belonging to this genus thus far reported from North America. It is one of the species of mollusks used by Clark and Vokes (1936) for intercontinental correlation of west-coast Eocene and European Eocene faunas. These workers have compared it to *Gisortia tuberculosa* (Duclos) from the Ypresian stage, Paris Basin, France. They state, "The California specimen [*Gisortia clarki* Ingram] is somewhat more globose and the outer lip is not as prominently reflected posteriorly as in the Paris Basin form [*Gisortia tuberculosa* (Duclos)]. The evidence indicates that in both species the spire was submerged beneath a callus wash."[2]

Gisortia clarki, n. sp.

Shell globose, heavy; posterior canal prominently produced, and covered dorsally by a shelf 8.5 mm broad on the outer side; dorsally on the columellar side this shelf narrows to a width of approximately 3 mm and slopes abruptly toward the ventral shell surface; posterior canal produced 11 mm; spire almost totally submerged beneath outer enamel, the spire peak projecting 3.5 mm from the body of the shell; a flattened surface persists to the left of the posterior canal; maximum width of posterior canal is 14 mm; estimated maximum width of anterior canal about 16 mm, a shelf with a maxi; mum width of 5 mm occupies the columellar side of the anterior canal-this shelf is angled dorsally from the shell base; the anterior canal is apparently compressed dorsoventrally at its outermost extremity; outer and columellar lips of aperture broadly rounded; aperture curves to the left anteriorly and posteriorly.

[3] VAUGHAN, T. W. U. S. Geol. Surv. Mon. 39: 78–80, pl. 5, figs. 13–19b. 1900.

[1] Received February 2, 1940.

[2] CLARK, B. L., and VOKES, H. E. *Summary of marine Eocene sequence of western North America.* Bull. Geol. Soc. Amer. 47: 851–878. 1936.

Dimensions—Length 121 mm, breadth 94 mm, height 64 mm.

Holotype.—Univ. California, Mus. Pal., invertebrate collection, no. 14844.

Type locality.—Locality no. 4052, Museum of Paleontology, invertebrate collection; Capay stage, Llajas formation, lower zone, Simi Valley, Ventura County, Calif.

The holotype specimen is moderately eroded on the dorsal surface. The greater part of the dorsal shell convexity is represented by an intact internal

Fig. 1.—*Gisortia clarki*, n. sp. Dorsal view. Approximately natural size.

mold. The shell substance is well preserved on the base, the extreme posterior region, columellar lateral shell boundary, and on the posterior three-fourths of the outer lip. The aperture is filled with a matrix, which prohibits a description of the internal surfaces of the columellar and outer lips.

This species is named in honor of Dr. Bruce L. Clark, of the Department of Paleontology of the University of California, Berkeley, Calif. The photograph used here was obtained through his courtesy. The holotype specimen was also sent to the writer by Dr. Clark.

BOTANY.—*Spore formation in* Matula.[1] G. W. MARTIN, State University of Iowa.

The genus *Matula* was established by Massee (Journ. Royal Micr. Soc. 1888: 173) to accommodate *M. poroniaeformis*, a fungus first described from Ceylon by Berkeley and Broome (Journ. Linn. Soc. Bot. **14**: 73. 1873) as *Artocreas poroniaeforme*. Berkeley believed that the species so named was congeneric with *Michenera Artocreas* Berk. and Curt., but by an error he transposed the generic and specific names of the latter species, writing it, in a note appended to the description of *A. poroniaeforme*, *Artocreas Micheneri*. Shortly afterward (Journ. Linn. Soc. Bot. **15**: 83. 1876) he corrected the error, without, however, actually publishing the combination *Michenera poroniaeformis*, which he had evidently meant to use in the first place but which seems to have been first printed in the Sylloge Fungorum **6**: 653. 1888. Lloyd (Myc. Writ. **3**: 443. 1909) examined the specimens at Kew and satisfied himself that Berkeley had really transposed the names, and Petch in connection with his careful study of the Ceylon species (Trans. Brit. Myc. Soc. **11**: 67–81. 1926) checked the situation independently and came to the same conclusion.

Massee restudied Berkeley's material and, believing that he saw basidia, made *Matula* the type and sole representative of a new "order" of Gasteromycetes, the Matuleae, which he regarded as intermediate between the Nidulariaceae and the Hymenogastraceae. Many years later Rick (Broteria **5**: 10. 1906), referring to what he regarded as a distinct species, *Michenera Rompelii* Rick, from Brazil, said: "Es gehört natürlich unter die Hymenogastrineae als Hemihymenogastria." Lloyd (Myc. Writ. **2**: 391. 1908) transferred Rick's species to *Matula*, and said, referring to both species: "The relations appear to be entirely with the Nidulariaceae." Petch, however, presents convincing evidence that the Ceylon species is an imperfect stage of *Peniophora habgallae* Cke.

Although Massee's supposed discovery of basidia seems clearly to be based on misinterpretation of what he saw under the microscope, his generic name has been very generally adopted. Petch, however, uses the generic name *Artocreas* on the ground that the species described by Berkeley as *A. poroniaeforme* is generically distinct from *Michenera* and was technically validly published. With this interpretation I can not agree. Berkeley believed his *A. poroniaeforme* belonged in the same genus as *Michenera Artocreas*, and his publication

[1] Received March 21, 1940.

of *Artocreas* as a genus was no more than the result of a trick of memory, as he himself pointed out. Such publication certainly does not comply with the conditions clearly stated in Article 37 of the International Rules. Massee was the first to recognize the generic distinctness of *Matula*, and, however erroneous certain of his conclusions may have been, his description does bring out the characteristics by which the genus may readily be recognized. So long as it is regarded as distinct from *Michenera*, his name should be applied.

Berkeley described the spores of *A. poroniaeforme* as 0.0009 inch in diameter (24–25μ). *Michenera Rompelii* Rick (Ann. Myc. **2**: 243. 1904) was based largely on the supposedly smaller spore size, less than 20μ. Lloyd reported the spores of both species to be 18–20μ in diameter and concluded they were probably the same. Petch, however, noted certain differences between them, particularly a continual basal layer beneath the cup in *Rompelii*, which he finds lacking in *poroniaeformis*, and concludes that it is doubtful whether they are identical.

A species of *Matula* was fairly common in western Panamá in July 1935, being represented by five collections. Four of these are from the valley of the upper Rio Chiriquí Viejo, above 1,600 m., and the other is from the forest south of the Llanos del Volcán between 1,100 and 1,200 m. I have also a single collection from the Sierra Nevada de Santa Marta, Colombia, between 1,250 and 1,500 m. gathered in August of the same year. In addition, I have examined one of Rick's collections from Brazil, now in the Lloyd Herbarium at Washington (no. 22541) and a collection of G. H. Cunningham's from New Zealand, now in the herbarium of the Missouri Botanical Garden. All, I am convinced, represent the same species. Some fructifications appear to have the continuous basal layer beneath the cup referred to by Petch as characteristic of the American forms, but others lack it, appearing in section, except for the absence of bark fragments imbedded in the fructifications, essentially like the forms illustrated by Petch in figures 1–5 of his plate 3. As in the Old World specimens, the fructification is at first subglobose and closed, opening above very early and assuming the characteristic cupulate form. The spores are borne in peridiole-like chambers, originating from the walls of these chambers. In the older portions near the surface the walls disappear, at which time this part has become a solid mass of the large, thick-walled spores, held together by their gelatinous walls (Fig. 2). The fructification is tough-gelatinous when fresh, drying somewhat horny, but readily regaining its original texture and appearance when soaked (Fig. 1). The temptation is strong to regard

the New World and New Zealand specimens, on the one hand, and the Ceylon specimens studied by Berkeley, Massee, and Petch, on the other, as referable to the same species. The manner of spore development in the former group, as I interpret it, differs decidedly, however, from Petch's account for the Ceylon form, and while a careful reading of Petch's paper makes it seem not entirely impossible that his is merely a different interpretation of the same structures, in the absence of opportunity to examine Ceylon collections, it seems proper to refer the specimens here discussed to *Matula Rompelii* (Rick) Lloyd.

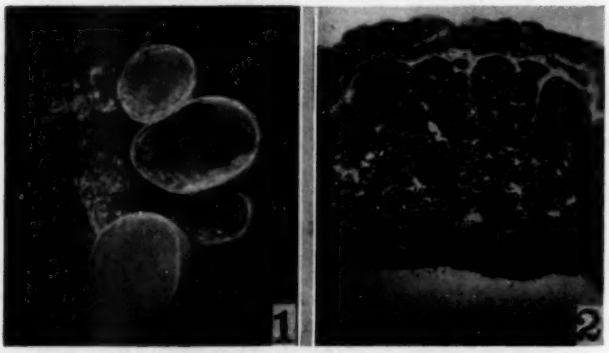

Fig. 1.—*Matula Rompelii* (Rick) Lloyd: Group of four fructifications, soaked, ×3.
Fig. 2.—*Matula Rompelii* (Rick) Lloyd: Longitudinal section through fructification near center, showing peridium, basal chambers, and solid mass of spores at surface, ×15.

According to Petch, the spores of *poroniaeforme* are borne on conidiophores that produce first a terminal spore, additional spores being borne basipetally. The lumen of the young spores stains deeply but the wall surrounding it remains hyaline and gelatinous, fusing with adjoining hyphae so that the outline is indistinct. Finally, the central protoplasmic mass develops an independent wall of its own, and the wall of the parent cell deliquesces, freeing the spore. We have, then, a conidium formed within a sac, surely a curious phenomenon. Petch argues that such a spore can not be a chlamydospore and regards the spore of *Matula poroniaeformis* as homologous with that of *Michenera Artocreas*, the essential difference being that in the latter species the wall of the mother cell persists as an apical appendage and a basal pedicel, while in the former species the wall gelatinizes and disappears. Petch notes that the hyphae of *Matula* bear clamp connections, but he makes no mention of any relationship between such structures and the spores.

In the American forms studied, including Rick's Brazilian collection, and also in the New Zealand material, clamp connections are abundant on the hyphae at the bases and sides of the spore sacs, where the spores are being formed (Fig. 3, *a*). but are only rarely and obscurely visible elsewhere. I have never seen any suggestion of conidiophores, as described by Petch. The spores seem always to originate as intercalary structures on the hyphae and always at the apical side of a clamp connection. This is uniformly apparent in the young spores but progressively less so as the spores mature. The contents of the apical cell are retracted toward the septum, causing a pronounced swelling (Fig. 3, *b*, *c*, *d*). The lumen stains deeply, while

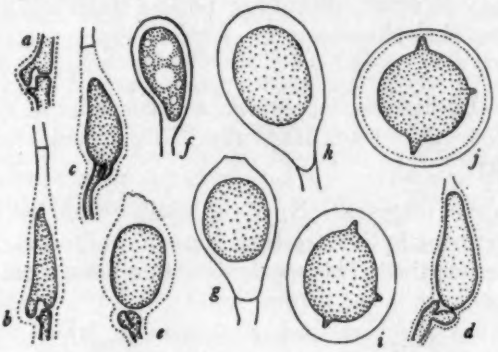

Fig. 3.—*Matula Rompelii* (Rick) Lloyd: *a*, A clamp connection from region of spore formation; *b*, *c*, *d*, early stages in spore formation, showing accumulation of protoplasm on distal side of clamp connection; *e*, *f*, *g*, *h*, progressive stages in development of spore; *i*, spore freed from basal hypha, projections arising from lumen; *j*, mature spore with double wall. All ×1,000.

the outline of the thick, gelatinous wall is very faint. Sooner or later this wall ruptures or is dissolved, and then the spore appears to be terminal (Fig. 3, *d*, *e*, *h*). Finally it breaks loose from the stalk and gradually becomes globose, apparently developing, in its later stages, at the expense of the gelatinous matrix in which it is imbedded. At complete maturity (Fig. 3, *j*) the lumen occupies approximately two-thirds of the total diameter of the spore. The wall is composed of two layers, an outer highly refractive portion, at complete maturity 0.6–0.8μ thick, and an inner clear layer 3–4μ thick or somewhat more. Occasionally the inner layer is divided by faint, concentric rings into two or more portions. Six or eight conical projections arise from the lumen and reach nearly or quite to the outer spore coat. Two or three of these are usually visible when the lens is focused on the optical center of the spore. It is not improbable that these represent germ-

pores. The outer wall above them appears, however, to be perfectly homogeneous. It seems clear that spores formed in the manner described can not be referred to as conidia, and the term chlamydospore comes nearer than any other to describing their true nature.

The spores of the Brazilian specimen are more variable in size than those of the Panamá and Colombia material, some of them reaching 28μ in diameter, and the peglike protrusions from the lumen, while often present, are usually fewer in number and sometimes not evident. I doubt whether such differences are of taxonomic significance.

No suggestion of possible connection with a perfect stage is to be found in any of the material at hand. Lacking information to the contrary it may be assumed that any perfect stage will prove to be a member of the Thelephoraceae.

ZOOLOGY.—Boccardia proboscidea, *a new species of spionid worm from California.*[1] OLGA HARTMAN. (Communicated by WALDO L. SCHMITT.)

The commonest representative of the family Spionidae, of the genus *Boccardia*, occurring in the intertidal zones of California, remains unnamed and undescribed. This species is of interest not only because it occurs in abundance in the littoral zones where it is readily available but also because of several biological features, which may warrant more thorough investigation.

My attention was first called to this species several years ago, when I was a member of Prof. S. F. Light's courses in invertebrate zoology at the University of California. At that time its designation was questionable, and after a perusal of the literature I (Univ. California Publ. Zool. **41**: 48. 1936) referred it to *Boccardia natrix* (Söderström) without, however, consulting Söderström's type materials. Since then the species has been noted many times along the coast of California. At the Scripps Institution of Oceanography, through the courtesy of Dr. Martin W. Johnson, it was possible to observe it also as an element in the plankton and to maintain adults and larvae under laboratory conditions.

This study has been supported through a grant from the American Association of University Women. I wish to express my thanks not only for the privileges already mentioned, but also to Dr. Waldo L. Schmitt, of the United States National Museum, for further courtesies.

[1] Received March 30, 1940.

Boccardia proboscidea, n. sp. Fig. 1

?Polydora californica Treadwell, Univ. California Publ. Zool. **13**: 203–204, pl. 12, figs. 23–29. 1914 (not *Spio californica* Fewkes, 1889, which is a *Polydora*, sensu latiore).

Boccardia natrix Hartman, Univ. California Publ. Zool. **41**: 48. 1936. Journ. Washington Acad. Sci. **26**: 32. 1936 (not *Polydora natrix* Söderström, 1920; *not* Berkeley, 1936).

The general form of the body is long, depressed, widest in the region of the eighth to sixteenth segments, and tapers gradually posteriorly. Number of segments is about 125 to 150; total length 30 to 35 mm but capable of much greater extension in life; greatest width (preserved) is about 1.5 mm. Color in life is deep yellow to orange, with bright-red branchial filaments, and considerable dusky pigment along the prostomial ridges and palpal grooves; in preserved individuals all color fades except the sooty markings along the prostomium and some along the palpal length.

The prostomium is an elongate, entire lobe, without median groove such as characterizes most species of this genus; a weakly developed emargination is visible only on the ventral side (Fig. 1, *a*). The lobe is snoutlike (for which the specific name is proposed), it extends posteriorly between the palpal bases where it forms a low crown visible in lateral view (Fig. 1, *d*) and passes more posteriorly as a low, broad ridge to the posterior margin of the third setigerous segment (Fig. 1, *b*). In the region just anterior to the insertion of the palpal bases there are two or three pairs of dark eye spots, clearly visible when the palpi are pushed somewhat to the side. In immature specimens there may be several additional dark spots in these areas, but at least two pairs persist even in the largest individuals. The prostomial lobe is sharply set off from the peristomium by grooves at the sides of the snoutlike elevation. The lateral and ventral sides of the oral opening are bounded by the apodous, achaetous peristomial ring (or first segment). Except for some longitudinal and transverse furrows and some wrinkles of contraction, it is quite smooth (Fig. 1, *a*, *b*, *d*).

The second segment (herein designated the first setigerous) is proximal to the peristomium; it bears a dorsal and a ventral fascicle of pointed setae, each provided with a small postsetal lobe (Fig. 1, *d*). These parapodial structures are comparatively weakly developed, less than half as large as those of the following segment, the setae both fewer in number and shorter. The second setigerous segment resembles the next two. There are well-developed setigerous fascicles, the dorsal and ventral postsetal lobes are auricular, and there is a long, filamentous branchia (Fig. 1, *d*). The fifth (modified) setigerous segment is nearly twice as long as the preceding; it is provided with a dorsal fascicle of stout hooks and an inconspicuous ventral fascicle of capillary setae (Fig. 1, *i*); there are no postsetal lobes. The stout hooks are of two kinds—a longer, falcate, smooth hook, accompanied by an equally heavy, though shorter, bushy-topped seta. In unworn condition (Fig. 1, *h*) the falcate spine terminates distally in a tapering fang; the other has a characteristic subterminal constriction, then widens suddenly and ends in a spinous cap that is strongly asymmetrical (Fig. 1, *h*). In worn condition both of these spines lose these characters (Fig. 1, *j*), but the cuplike base of the latter is still notable.

The next (sixth setigerous) segment is provided with pointed setae in both dorsal and ventral fascicles; its structures are similar to those of the second to fourth segments, but the postsetal lobes are progressively larger. From the seventh the neuropodium is provided with about eight hooded

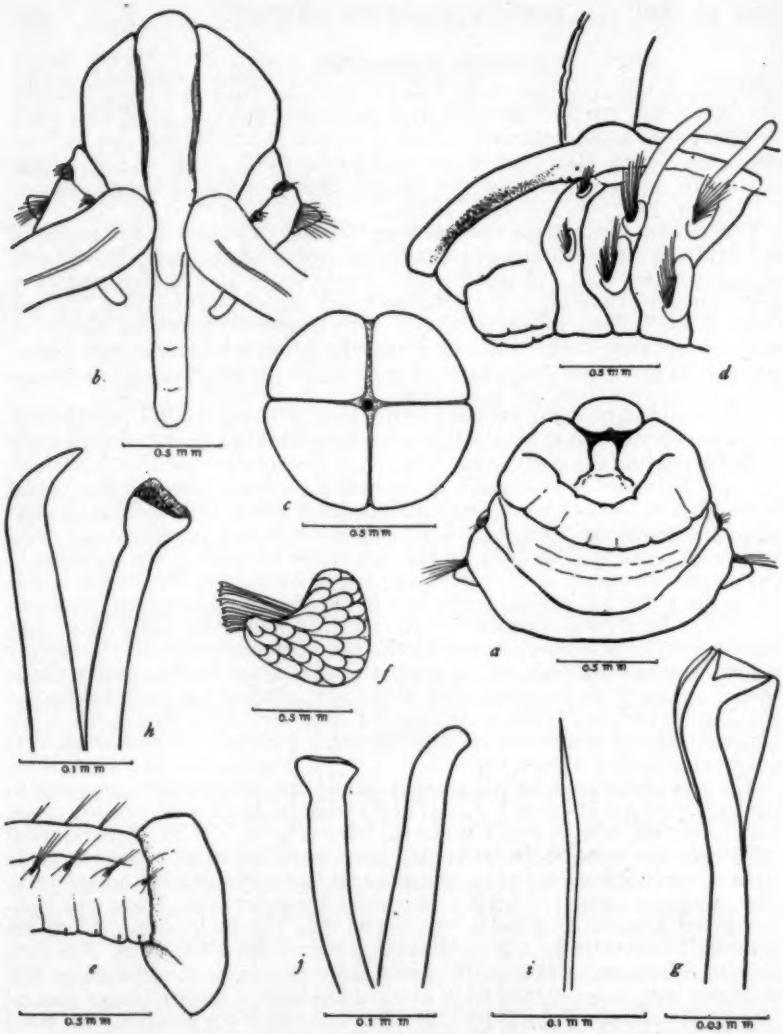

Fig. 1.—*Boccardia proboscidea*, new species: *a*, Anterior end, in ventral view, showing the rounded margin of the prostomial lobe and the peristomial ring bounding the oral aperture, followed by the first two setigerous segments; *b*, the same, in dorsal view, with only the palpal bases shown, the prostomial caruncle continued posteriorly; the eye spots are largely hidden because of their position at the sides of the prostomial lobe; *c*, anal disk in posterior view, showing the 4-lobed arrangement; *d*, anterior end from the left side, the left palpus removed so that the eyes may be seen, setal fascicles indicated; *e*, posterior end from the left side, showing the prolongation of the ventral lobes of the disk; *f*, parapodial gland from the ninth segment seen from the front, showing its characteristic outline; *g*, hooded crotchet from tenth neuropodium; *h*, companion stout setae from the fifth setiger in unworn condition; *i*, pointed seta from inferior fascicle of the modified fifth setigerous segment; *j*, worn companion setae from the fifth setigerous segment.

crotchets, disposed in a single vertical series, and a smaller, inferior fascicle of about five or six slender, pointed setae. The latter persist through about four segments, but from the eleventh there are only hooded crotchets. Notopodia are provided with only pointed setae throughout. Hooded crotchets of anterior and posterior segments resemble one another. The distal end is bifid, the lateral fang nearly at right angles to the main stem, the distal tooth smaller (Fig. 1, *g*).

Branchiae are distributed on setigerous segments 2 to 4, and from the sixth to near the posterior end; the last few (two to four) segments are abranchiate. Setigerous glands, characteristic of members of this family, are best developed posterior to the modified segment; they form a thick, sacklike, slightly L-shaped, pouch (Fig. 1, *f*), terminating under the body wall adjacent to the hooded hooks. The last setiger is followed by a broad, flaring anal disk (Fig. 1, *c*, *e*) unequally 4-lobed, the dorsal lobes the smaller. The anal aperture lies in the depression near the center of the disk (Fig. 1, *c*).

B. proboscidea is thus characterized in having branchiae distributed on setigerous segments 2 to 4, and from segment 6 nearly to the posterior end; the first setigerous segment has weakly developed nodopodial and neuropodial fascicles; hooded crotchets are present from the seventh, the first few accompanied by an inferior fascicle of pointed setae, the rest forming a single series of hooks only; the prostomial lobe is long, entire, snoutlike, without median emargination; it is continued posteriorly as a ridge to the posterior margin of the third setigerous segment; the modified segment is provided with smooth falcate setae and bushy-topped setae in which the spinous area is asymmetrical. Its affinities are with *B. polybranchia* (Haswell), from which it differs in its entire prostomial lobe and in having setal fascicles both dorsally and ventrally in the first setigerous segment. Another nearly related species is *B. natrix* (Söderström), but this has well-developed parapodial lobes on the first setigerous segment and the prostomial lobe is bifid; also the bushy-topped setae have paired bosses subdistally.

Holotype.—U.S.N.M. no. 20217. Caspar, Calif.

Distribution.—*B. proboscidea* inhabits a great variety of niches in the intertidal zones of California, south at least to San Diego and north to Mendocino, but its range may extend north to Puget Sound, Wash. It has never been encountered in dredged collections from deeper water. Careful investigations in other areas, however, may extend these ranges.

Biology.—*B. proboscidea* is conspicuously abundant in shale and limestone reefs, penetrating the softer rocks, boring usually at right angles to the surface, and sometimes present in such numbers as to cause the rock to break away. It is also an interesting dweller in high tide pools, where hollows are formed in sedimentary rocks. In such places the minute burrows of the spionid may be observed at the apertures of which the two long, waving palpi of the worm reach far out, after particles of food in the vicinity. A common association in such pools is with a small red harpacticoid copepod, of the genus *Tigriopus*, on which the spionid feeds. Prof. S. F. Light, of the University of California, has often called attention to this association, as well as to the high incidence of the *Boccardia* in these areas. An abundance of the latter is usually correlated with small numbers of *Tigriopus*. Its presence in such habitats is also indicative of great tolerance for variations in

salinity and temperature. Another favorite habitat is in narrow crevices in intertidal zones. Under such conditions a loosely constructed tube surrounds the individual.

B. proboscidea is a voracious predator, feeding not only on algal particles, Bryozoa, Hydrozoa, and other attached organisms but actually capturing free-swimming animals. The greatly extensile, prehensile palpi are the chief organs of food getting; the tip senses out favorable objects for ingestion and is firmly wrapped about any desirable object that is nipped off, taken up in the ciliary groove, moved orally, and swept into the mouth.

Only fragmentary information is known of the life history. The eggs are deposited in ovoid capsules, 50 or more eggs in each, and five or more capsules in a tube. Aeration, produced by rhythmic movement of the adult, is continued while the young develop. The rate of development in any one capsule may be about equal for the various individuals, or very irregular. Development is fairly rapid and can be conveniently observed because of the ease with which they develop under laboratory conditions.

Capsules collected from the tube of a single adult differ among themselves. Some will have numerous larvae, all in a similar stage of development, with as many as 40 or more rapidly moving young. When such a capsule is split open there is a great scurry to escape. If given nourishment, they flourish as plankton organisms and after some weeks metamorphose into settling young. In other capsules there may be only one or two much larger larvae, cannibalistic on the other contents in the capsule, and escaping only when all food has been used. Whether the other eggs fail to develop because of injury or some enzymatic influence has not been ascertained. At any rate, when such young emerge they are ready to settle immediately. Incidence of the larvae in the plankton is readily observed because of a unique pigmentation pattern; already in a 7- to 9-segmented stage the modified segment is differentiated.

Systematic discussion.—Several species of *Polydora* (sensu latiore) have been described from the west coast of the Americas, but the status of some of them is still in doubt. Unless type specimens are extant, some of the names may need to be dropped. The first spionid to be described from California was *Spio californica* Fewkes (Bull. Essex Inst. **21**: 37–38. 1889) from Santa Barbara. It is difficult (perhaps impossible) to know what this is, but it must be considered in this discussion because of the statement, "On the second, third and fourth body segments, counting from the head, we find a dorsal and ventral bundle of setae, and a dorsal and a ventral cirrus. The ventral cirrus [postsetal lobe?] is smaller than the dorsal. **In the fifth body segment** [modified segment?] there is a fan-shaped, deeply embedded bundle of large spines in addition to the dorsal and ventral clusters." There is, however, no mention of the distribution of branchiae, nor is it clear that the author distinguished between branchiae and postsetal lobes, nor what is meant by dorsal and ventral cirrus. It is not possible to distinguish it as either a *Boc-*

cardia or *Polydora* (sensu stricto). There is another statement regarding its tubes, which contradicts its inclusion in the family Spionidae: "The tubes . . . resemble those of *Sabellaria* but differ from them in color, size, and form of the openings. The edges of the orifices are sharper and the tubes themselves are more compact." I know of no spionid which constructs such tube masses. However, the head is said to have "two long tentacles" (as in Spionidae) but they are described as papillated (Magelonidae??). Other features exclude it from the latter. I am unable to regard this as anything more than a *Polydora* in the broad sense.

Later *Polydora californica* Treadwell (Univ. California Publ. Zool. **13**: 203–204, pl. 12, figs. 23–29. 1914) was described, its locality given as unknown. I have seen the single incomplete specimen, deposited in the collections of the University of California. It may be the same as the species herein described, but since the name turns out to be a questionable homonym, it should be replaced by another. A few years ago, while going over the collections at Berkeley, I reported this as *B. natrix* (Univ. California Publ. Zool. **41**: 48. 1936), and identified Treadwell's name with it. Since then, I have seen Söderström's type of *B. natrix* and found it to be something quite different. Through the courtesy of Prof. Sixten Bock, of the Swedish State Museum at Stockholm, these materials were made available. The results are being reported on in a separate study. It is sufficient here to say that *B. natrix* is an inhabitant of a sponge, from a depth of 135–150 meters, off southern South America, that it is clearly separable morphologically from the California species, and that *B. natrix* can not be applied to the latter. *B. natrix* has a prostomial lobe that is clearly bifid at its anterior margin, the groove continued for some distance along the dorsal surface; there are eye spots but differently disposed; the first setigerous segment has unusually well developed fascicles and postsetal lobes, nearly or quite as large as those of the following segments, and the modified hooks of the fifth segment are provided with paired lateral bosses. *Polydora* (*Boccardia*) *natrix* was later reported by Berkeley (Ann. Mag. Nat. Hist. (10) **18**: 472. 1936) from the Nanaimo district. These specimens are partly described, showing therein differences from Söderström's species, but differing also from *B. proboscidea*. Dr. Berkeley recorded the absence of eyes and described the prostomium as bifurcate.

ZOOLOGY.—*Notes on the amphipod* Gammarus minus *Say and description of a new variety,* Gammarus minus *var.* tenuipes. CLARENCE R. SHOEMAKER, U. S. National Museum.[1]

Thomas Say (1818, p. 376) described *Gammarus minus* as follows:

> Eyes reniform; superior antennae longer than the inferior ones, terminal joint with about twelve articulations. Inhabits rivulets and small fresh-water streams. Body whitish, with a few very pale fulvous lateral spots; eyes blackish, placed at the exterior base of the superior antenna; superior antennae obviously longer than the inferior ones, seta short, attaining the tip of the second articulation of the terminal joint, terminal joint with about twelve articulations. Length three-twentieths of an inch. Found in brooks under stones, and may be readily discovered by taking a stone out of the water, and inspecting its inferior surface.

His description would be quite inadequate for the recognition of the species, except for his mentioning that the first antennae are obviously longer than the second and that it inhabits rivulets and small fresh-water streams. It is, as he states, an inhabitant of the small streams, and, though he does not say streams of the east coast, he undoubtedly means such, as all the other amphipods he described were from the east coast. It is a very common and widely distributed species of the cold streams of the eastern section of the United States, in contradistinction to *Gammarus fasciatus* Say, which inhabits the warmer waters of our eastern rivers.

Though *Gammarus minus* is so common and widely distributed, there have been comparatively few references to it in literature since its discovery in 1818. H. Milne Edwards (1840, p. 46) says that the species described by Say under the name of *Gammarus minus* does not seem to differ in any important character from *G. fasciatus* and it will perhaps be necessary to unite them. A. A. Gould (1841, p. 334) says, "Found [in Mass.] in ditches and sluggish fresh water, adhering to sticks." Since the habitat he cites does not seem suitable for *G. minus,* it is doubtful whether his reference applies to this species. J. E. DeKay (1844, p. 37) says, "This species is common [in New York] in most of our fresh-water streams, and may often be detected under stones and pieces of wood. It is extremely active, and is popularly known under the name of *Fresh-water Shrimp.*" He gives a short description, but fails to add any useful characters, and he also gives a very small inaccurate figure. Adam White (1847, p. 88), in his *List of the specimens of Crustacea in the collection of the British Museum,*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 11, 1940.

uses the name *Gammarus minimus* Say and gives the locality as United States; specimens presented by Thomas Say. Spence Bate (1862, p. 221), in *Catalogue of the specimens of amphipodous crustaceans in the collection of the British Museum*, repeats Say's description and habitat.

Sidney I. Smith (1874, p. 654) says, "I have not yet been able to rediscover this species, which is very likely not a true *Gammarus*." He believes that the specimens referred to by White and Bate were the ones that Bate described as *Allorchestes knickerbockeri* (1862, p. 36). Lucien M. Underwood (1886, p. 357) mentions the species as occurring doubtfully in New York. Thomas R. R. Stebbing (1906, p. 513) puts *G. minus* in the list "Gammari nominatim, reapse incertae sedis." Henry W. Fowler (1912, p. 194) in *The Crustacea of New Jersey*, lists *Gammarus minus* Say and questionably *Lepleurus rivularis* Rafinesque as synonyms of *Gammarus fasciatus* Say. From the localities he cites for *G. fasciatus* it is quite evident that he is dealing with both *G. fasciatus* and *G. minus*.

As the references to *Gammarus minus* in literature add nothing to Say's inadequate diagnosis, I here redescribe and figure the species from specimens collected by John W. Price from a small stream at Gable's Woods, Lancaster, Pa., on March 6, 1936. As Say did not designate any locality, a male from this lot has been selected as the neotype, U.S.N.M. no. 79152. I have selected this locality for the neotype because Say collected *G. fasciatus* at Philadelphia, and it is probable that he also collected *G. minus* in the brooks of the surrounding country, which would be only about 60 miles from Lancaster.

Gammarus minus is placed by Dr. A. Schellenberg (1937, p. 270) in the subgenus *Rivulogammarus*, which he established for those almost exclusively fresh-water species of the cold and temperate regions of the northern half of the earth. He characterized this subgenus as having the side lobes of the head truncate or rounded off without the sharp upper corner. Eyes mostly small, oval or kidney-shaped. First and second urosome segments without or with only weakly developed central humps and with only one pair of central spines. Third urosome segment mostly without central spines. A part of the urosome spines sometimes replaced by bristles. Accessory flagellum 1- to 6-jointed. Lower margin of the coxal plates mostly unbristled. Metacarpus of the first gnathopod of male with peglike spines on rear margin. Rami of the third uropod varied in length, but the inner ramus never reduced to a scalelike joint.

Gammarus (Rivulogammarus) minus Say Figs. 1, 2

Gammarus minus Say, Journ. Acad. Nat. Sci. Philadelphia 1(2): 376. 1818.
G. propinquus Hay, Proc. U. S. Nat. Mus. 25(1285): 224. 1902.
G. purpurascens Hay, Proc. U. S. Nat. Mus. 25(1292): 433, fig. 7. 1902.

Male.—Head with lateral lobes squarely truncate, upper and lower angles of lobes rounding. Eyes large, black, reniform, and slightly broader below. Antenna 1 about two-thirds the length of the body and considerably longer than antenna 2; first joint of peduncle a little longer than second, which is about twice as long as third; flagellum of about 30 joints; accessory flagellum of three or four long joints and a very minute terminal joint. Antenna 2, gland cone of second joint prominent; third joint prominent; fourth and fifth joints about equal in length; flagellum nearly as long as fourth and fifth joints combined and consisting of about 14 joints, the first five or six of which bear calceoli.

Right mandible with cutting edge rather narrow and armed with four teeth; accessory plate with double cutting edge; five spines in spine row; molar strong and bearing two short plumose setae on front margin and a long seta on inner margin; second joint of palp slightly longer than the third. Inner plate of maxilla 1 with about 16 plumose setae; outer plate with 11 spine teeth, some of which are blunt and some pectinate; palp of right maxilla broad, armed distally with four or five stout teeth, one slender pectinate spine tooth, and one slender plumose seta; palp of left maxilla with about seven slender spine teeth and four slender setae. Maxilla 2 normal and bearing the usual oblique row of plumose setae on inner plate. Maxillipeds with inner plate narrower, but nearly as long as outer plate, bearing distally three spine teeth and numerous slender curved plumose spines, inner margin bearing long, slender, plumose setae and one short spine near the upper angle; outer plate armed with a row of spine teeth on distal inner margin, a row of curved plumose setae on distal margin and numerous submarginal setae near the inner margin; palp rather short and stout, third joint with a low distal lobe, the inner edge of which extends obliquely across the inner face of the joint bearing a row of serate spinules; fourth joint rather slender and armed distally with a fine nail at the base of which are several closely set setules. Lower lip with broad blunt side lobes.

Coxal plates 1 to 3 bearing a few spinules at the rounding anterior and posterior corners. Coxal plate 4 bearing a few setules at anterior corner and a row on the lower posterior margin. Sixth joint of gnathopod 1 with the very oblique palm bearing a stout central spine and a stout defining spine, hind margin and inner surface of joint bearing several short blunt spines. Sixth joint of gnathopod 2 with front and hind margins about parallel, the oblique palm bearing a stout central spine and two stout spines at the broadly rounding defining angle, inner surface of joint bearing two small submarginal spines at defining angle. Peraeopods 1 and 2 very similar in structure, but 1 the longer and stouter and bearing longer and more numerous bristles. Second joint of peraeopod 3 broad, with the lower hind margin forming a prominent angle. Peraeopods 4 and 5 about equal in length, second joint with distinct lower hind angle.

Metasome segments 2 and 3 with lower hind corners sharply produced, lower margins bearing spinules and hind margins setae. Urosome segments 1 and 2 somewhat raised dorsally, and each bearing the two median dorsal spines characteristic of the subgenus *Rivulogammarus*. Urosome segment 3 may have either one or two median dorsal spines, or it may be without any,

but there are always median setae. Urosome segments 1 to 3 may bear either one or two lateral spines on either side. All urosome spines are accompanied by setae or bristles.

The number of spines on uropods 1 and 2 varies with the size of the specimen, but the number is always small. Uropod 3 with inner ramus about two-thirds the length of the outer, and both rami furnished on their margins with fascicles of long setae. Outer ramus without plumose setae on the second joint or apex of first joint; outer margin of first joint with a plumose seta in each fascicle except those which contain spines; inner margin with a plumose seta in each fascicle. Inner ramus without plumose setae on apex, but outer and inner margins with a plumose seta in each fascicle.

The telson varies somewhat in different individuals; the general arrangement being a single lateral spine accompanied by several setae, three apical spines with long setae on each lobe, and a group of lateral setae near the apex of each lobe. Occasionally there is an extra lateral spine either above or below the regular lateral spine. Length of the largest males about 16 mm.

Female.—The gnathopods are smaller than in the male, and the fifth and sixth joints of gnathopod 2 are much narrower and are about equal in length. Antenna 2 bears no calceoli. Uropod 3 shorter than in the male.

Remarks.—There are in the National Museum females of *Gammarus minus* from the District of Columbia carrying eggs each month from January to August. There are hatched young in the marsupium in January, April, May, June, and August. Free-swimming young are found in January, April, July, and August collections. There are no specimens taken in the District of Columbia from September to December, but specimens from Virginia and Pennsylvania taken in November and December carry eggs. It appears, therefore, from these records that the species breeds throughout the year.

Specimens of *G. minus* from a cave at Speed Creek, about 8 miles northeast of Bedford, Lawrence County, Ind., and those from a cave on the Mullindore property, Rohrersville, Washington County, Md., differ very slightly from the normal surface water form.

In the National Museum there are collections of *G. minus* from Pennsylvania, Maryland, District of Columbia, Virginia, West Virginia, Indiana, Tennessee, Kentucky, and Georgia.

I have examined the type material of *Gammarus propinquus* Hay from a spring about 2 miles north of Mammoth Cave, Ky., and of *G. purpurascens* Hay taken at the mouth of Nickajack Cave, Shellmound, Tenn., and I find that they do not differ specifically from *G. minus* Say. Hay does not give the measurements of either species, but the largest specimens of *G. propinquus* are about 10.5 mm from the front of the head to the tip of the third uropods, and those of *G. purpurascens* are about 10 mm. The specimens collected by Hay in spring at Rossville, Ga. (referred to in Proc. U. S. Nat. Mus. **25**: 434. 1902) and identified as *G. purpurascens*, are in the National Museum. They are all of medium size, the largest about 9 mm and are undoubtedly *G. minus* Say.

The *Lepleurus rivularis* of Rafinesque (1820, p. 7) said to occur in the brooks of the mountains of Pennsylvania and at Shannon Run and Bedford

Springs, Va., is probably the *Gammarus minus* of Say, but Rafinesque's description is so imperfect that nothing can be learned from it.

Gammarus minus var. tenuipes, new variety

Specimens from Organ Cave, Greenbrier County, W. Va., found in a stream a quarter of a mile in from the entrance, appear to be a subterranean variety of *Gammarus minus.* These specimens have the eye greatly reduced and occasionally almost entirely lacking. The lateral lobes of the head have the corners very rounding. The gnathopods and peraeopods are slender, especially noticeable in the narrowing of the second joint of the last three peraeopods. In some of the specimens there is a reduction in the number of spines on the urosome. The inner ramus of the third uropod is proportionately longer than in the normal form. The whole animal has a weaker and more delicate appearance than the surface form. Length about 14 mm.

The type, a male, U.S.N.M. no. 79195, was taken in Organ Cave, Greenbrier County, W. Va., on October 21, 1939, by T. Kenneth Ellis.

The National Museum has also a specimen of this variety from McClung's Cave, West Virginia, and several from Higgenbotham's Cave, Frankford, Greenbrier County, W. Va., collected by J. M. Valentine.

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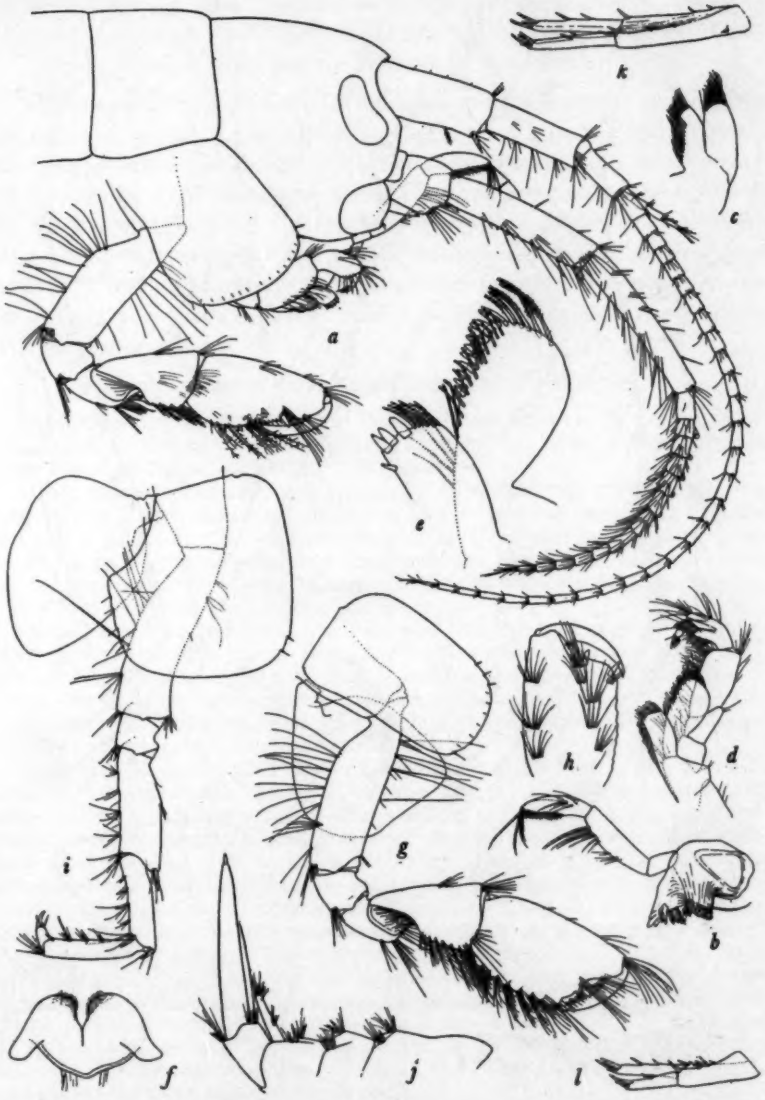

Fig. 1.—*Gammarus minus* Say, male: *a*, Anterior end of animal; *b*, right mandible; *c*, maxilla 2; *d*, right maxilliped; *e*, inner and outer plates of maxilliped on larger scale; *f*, lower lip; *g*, gnathopod 2; *h*, inner surface of metacarpus of gnathopod 2; *i*, peraeopod 2; *j*, urosome; *k*, uropod 1; *l*, uropod 2.

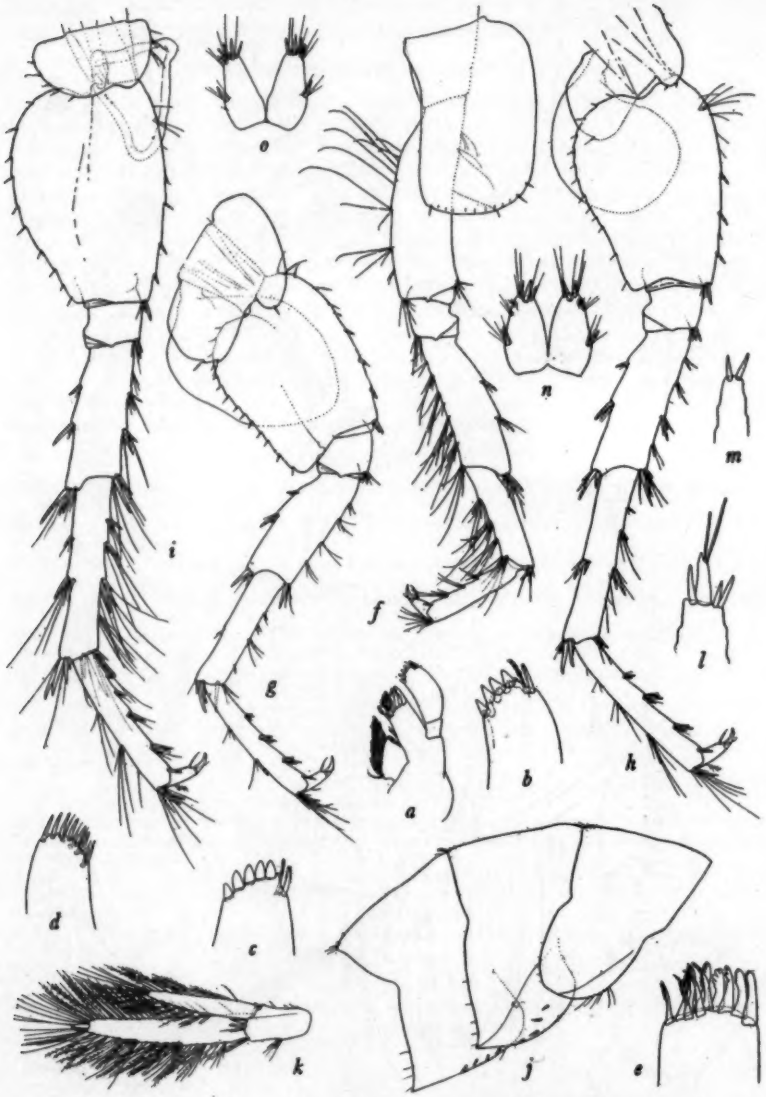

Fig. 2.—*Gammarus minus* Say, male: *a*, Right maxilla 1; *b*, palp of maxilla 1 on larger scale; *c*, palp of another male showing five spine teeth; *d*, left palp showing terminal spines; *e*, distal end of outer plate of maxilla 1 showing the 11 spine teeth; *f*, peraeopod 1; *g*, peraeopod 3; *h*, peraeopod 4; *i*, peraeopod 5; *j*, metasome; *k*, uropod 3; *l*, *m*, apex of outer and inner rami of uropod 3 on larger scale; *n*, telson; *o*, telson of another male. The figures of telson are on a slightly larger scale than the uropods.

ZOOLOGY.—*A new harpacticoid copepod from North Carolina.* R. E. COKER and JUANITA MORGAN, University of North Carolina. (Communicated by WALDO L. SCHMITT.)

Harpacticoid copepods collected by a graduate student, Paul McKee, from Baker Lake (Bladen County), Swamp Pond (Craven County), Odum's Millpond (Cumberland County), and other waters of eastern and southeastern North Carolina were found to resemble in many respects both *Canthocamptus staphylinoides* Pearse (1905) and the subspecies that the senior author has described as *sinuus* (1934). There are, however, such notable points of difference from one or both of these forms that it merits at least subspecific designation. We have named it:

Canthocamptus staphylinoides vagus, new subspecies

Holotype.—Female from Swamp Pond, Craven County, N. C., U.S.N.M. no. 79249. Collected by Paul McKee, January 16, 1938. Males have not been found. (McKee and Coker, 1940.)

Diagnosis.—Second foot conforming to the type; vestigial seta of fifth foot rather long—about one-sixth the length of outermost seta; relative lengths of spines on that segment about as in *C. staphylinoides;* anal spines small, 10 to 12 in number; many small spinules just lateral to the straight mesial borders of furcal rami on ventral side. (Now known only from waters of the lower Coastal Plain in North Carolina.)

Description.—Second foot: The endopod has only one seta on the inner border of the third segment (Fig. 1, *c*) where *sinuus* has two (Fig. 1, *j*); apparently it is the distal seta that is lacking. Pearse did not describe or figure this foot, but copepods we have from Massachusetts seem to agree in every other particular with the description of *C. staphylinoides* and are found to have only one seta in the place mentioned.

Fifth foot: Examples from Baker Lake have a distal joint of the fifth foot virtually identical with that of *C. sinuus,* but the short seta between the bases of the outermost setae of the proximal segment is distinctly longer than the corresponding seta of *sinuus* or of *staphylinoides* from Massachusetts (compare Figs. 1, *e,* and 1, *a,* with Figs. 1, *k,* and 1, *g*). The third well-developed seta, counting from the outer border of this segment, is distinctly shorter than the fourth, whereas in *C. sinuus* (Fig. 1, *k*) the two are approximately equal; in this respect the copepods in question are like *C. staphylinoides* (Fig. 1, *g*). The copepods from Swamp Pond (Fig. 1, *a*) have all spines, except perhaps the two outermost setae and the innermost seta of the distal joint, decidedly shorter, blunter, and stronger. The short seta of the proximal segment is intermediate between that of Baker Lake and *C. sinuus,* but its length, relative to that of the longest spine, conforms roughly with the corresponding relation in the Baker Lake copepods. This is true also of the third well-developed spine.

Caudal furca: The form of the furca (Figs. 1, *b, f*) is quite unlike that characteristic of *C. sinuus* (Fig. 1, *i*) but like that of *C. staphylinoides* (Figs. 1, *l, h*). On each branch of the furca there is a submarginal row of fine spinules or setae on the ventral surface a little lateral to the inner margin (Figs. 1, *b, f*); these spinules are not well seen until the furca is turned at an angle,

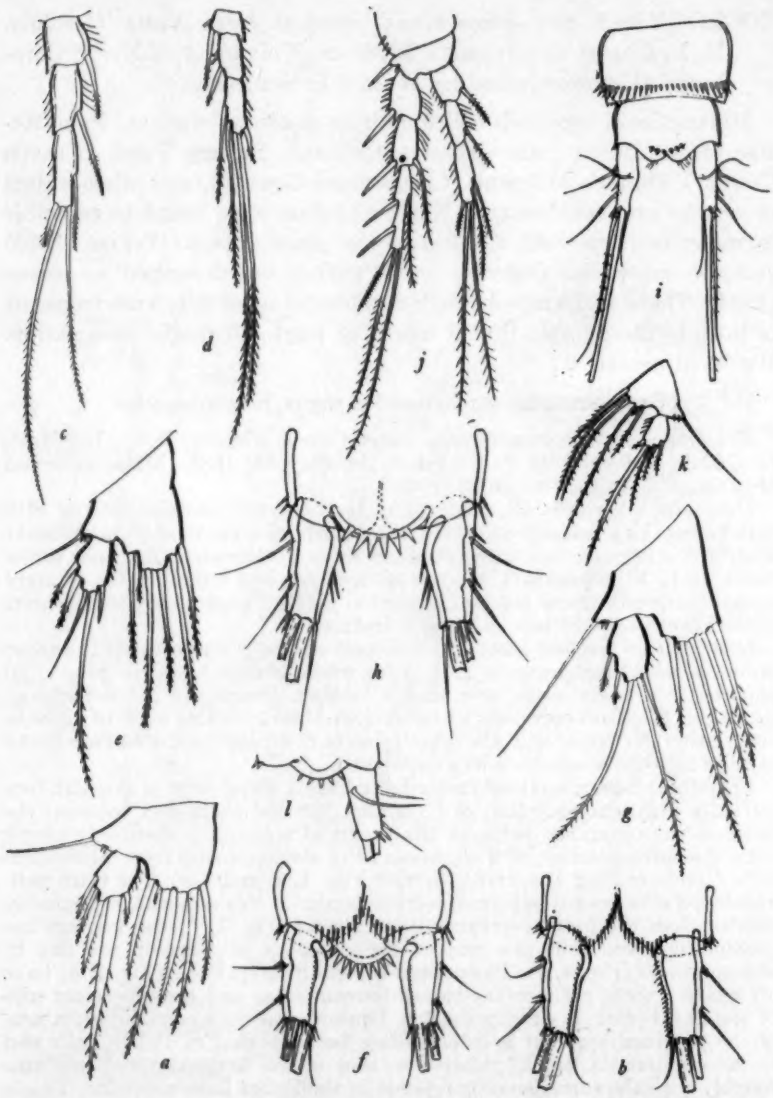

Fig. 1.—*Canthocamptus staphylinoides vagus*, holotype, female, from Swamp Pond: *a*, Fifth foot; *b*, furca—ventral aspect, slightly turned. *Canthocamptus staphylinoides vagus* from Baker Lake: *c*, Endopod of second foot, female; *d*, endopod of third foot, female; *e*, fifth foot; *f*, furca. *Canthocamptus staphylinoides* (s. str.) from Massachusetts: *g*, Fifth foot; *h*, furca—dorsal. *Canthocamptus staphylinoides* (after Pearse, 1905): *i*, Furca. *Canthocamptus sinuus* (from Coker, 1934): *j*, Second foot, female; *k*, Fifth foot; *l*, furca.

as shown in Fig. 1, *b*. The furca of the Massachusetts copepod (Fig. 1, *l*) seems to be typical of *C. staphylinoides* as described and illustrated by Pearse (Fig. 1, *h*), with a few rather strong setae showing on the inner margin or ventrally.

Anal plate: The spinules of the anal plate (Figs. 1, *b*, *f*) are relatively small, there being 10 on the examples from Baker Lake, 12 on those from Swamp Pond. The number in *C. sinuus* (Fig. 1, *i*) and *C. staphylinoides* (Fig. 1, *h*) is about 6, and the spinules are distinctly stouter.

The differences between the copepods from Baker Lake and those from Swamp Pond are insignificant. In respect to the fifth foot, the differences between these copepods on the one hand and either *C. staphylinoides* or *C. sinuus* are also inconsiderable.

Remarks.—Comparison of the new copepod with the previously described forms is given in the following table, where the mark "X" is used when the character is common to two, and the mark "—" where a distinctive character is found.

Species	Second foot	Rudimentary seta	Fifth[1] foot	Anal spines	Furca form	Armature
C. staphylinoides	X	X	X	X	X	—
C. s. vagus n. subsp.	X	—	X	—	X	—
C. sinuus	—	X	—	X	—	—

[1] Relative lengths of seta on first segment.

Since *C. sinuus* may now be presumed to differ from *C. staphylinoides*, not only in the form and armature of the furca, but also, and significantly, in the armature of the second foot, it should be regarded as a distinct species. The furca is unmistakable at a glance.

For direct comparison with the foregoing diagnosis of *C. s. vagus* we present here diagnoses of *C. staphylinoides* Pearse and *C. sinuus* Coker (here raised to the status of a species; described by Coker, 1934), the only other members of the restricted genus *Canthocamptus*, as defined by Chappuis and followed by the senior author in *Contribution to knowledge of North American freshwater harpacticoid copepod Crustacea*, 1934, now known to occur in the United States.

C. staphylinoides Pearse: Characters of the genus (both rami of second to fourth swimming feet 3-jointed, a vestigial seta on mesial expansion of fifth foot, etc.); second foot with one seta on inner border of third segment of endopod; short seta between bases of two outermost setae of proximal segment of P5 very short—about one-twelfth as long as the adjacent outermost seta or shorter; third well-developed seta of that segment, counting from the outermost border, shorter than fourth; anal spines large, 6 to 8 in number; a few prominent spinules on the straight mesial side of each furcal rami. (Now known only from Northern United States and Canada.)

C. sinuus Coker: Second foot with two setae on inner border of third segment of endopod; vestigial seta of P5 about as in *C. staphylinoides;* third well-developed seta on that segment about equal to fourth; anal spines 6 to 8 in number; mesial profile of furcal rami *sinuous* and *unarmed.* (Known from Connecticut, New Jersey, and North Carolina.)

Our new copepod is nearer to *C. staphylinoides* than to *C. sinuus* in the second foot, the fifth foot, and both the form and armature of the furca, although it differs from the former in the rudimentary seta of the fifth foot, the anal spines, and the armature of the furca. Since, however, the differences between our copepod and *C. staphylinoides* are quantitative and may be presumed to be subject to considerable variation, I would propose only a new subspecific name *vagus*, referring to its apparent habit of wandering out into open water. Harpacticoid copepods are characteristically littoral in the extreme and it is worthy of note that this copepod was taken repeatedly in plankton hauls during a survey covering 45 waters. The only other harpacticoid encountered was *C. sinuus* in one collection from a shallow swamp lake.

Some of the older lists of American harpacticoid copepods include *C. staphylinus* Jurine, but it is very probable that the records of the European species, which is clearly distinguishable by the conspicuous blunt, spinelike projection on the posterolateral margins of the fifth abdominal segment, as well as by other characters, are attributable to errors in identification. We know of one such case.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

1155TH MEETING

The 1155th meeting was held in the Cosmos Club Auditorium, Saturday, October 14, 1939, President BRICKWEDDE presiding.

Program: T. F. W. BARTH, Geophysical Laboratory: *Geysers and other hotsprings in Iceland.*—The thermal activity in Iceland, which is but one phase of the recent volcanicity, is not equaled in intensity or extent by any other region. Pioneers of our modern science, men like Bunsen, Descloizeaux, and others, visited Iceland to study these phenomena, and through their work the local name of the most famous spouting fountain in Iceland at that time, viz., "Geysir" (meaning "spouter") was accepted as a general term for hotsprings of this type.

The acid springs are intimately associated with recent volcanic activity, the alkaline springs are more independent in this respect, but are clearly most plentiful in areas possessing a superior water supply. Both acid and alkaline springs may show geyser action. Some of the geysers form deep wells, but measurements show that, although the temperature increases with depth, the boiling point is not reached at any depth—this is also true for the Great Geysir, which is 27 m deep.

The biggest boiling stream in the world is a copious spring in western Iceland the discharge of which is nearly 300 liters per second. The thermal energy it carries with it is approximately 140,000 horsepower. (*Author's abstract.*)

A. NADAI, Westinghouse Electric and Manufacturing Co.: *Formation of surfaces of slip under plastic states of stress.*—A characteristic phenomenon accompanying the plastic deformations of natural rock materials or of the ductile metals is the formation of very regular markings on the surface of test specimens. They are the traces of deformations localized in thin layers of the material which become plastic under the given system of forces. The laws of the formation of these slip layers are not yet fully understood and are rather intricate. Several important factors are required to be satisfied for the localized yielding of materials, which were discussed. Formation of regular spirals around a punch mark was shown for mild steel. Similar lines seem to mark the location of secondary cones on certain volcanoes in Japan. The formation of faults in geology seems to follow similar laws than the one describing slip in metallic materials. A motion picture was shown on the formation of gliding lines in mild steel bars. (*Author's abstract.*)

The first paper was discussed by Messrs. WRIGHT and GISH; the second one by Messrs. HAWKESWORTH, GISH, ROLLER, MAXWELL, and BRICKWEDDE.

1156TH MEETING

The 1156th meeting was held in the Cosmos Club Auditorium, Saturday, October 28, 1939, President BRICKWEDDE presiding.

Program: K. H. BEIJ: *Model testing at the National Hydraulic Laboratory.*—The National Hydraulic Laboratory is authorized to conduct general research in hydraulics on problems of its own choice and to work on specific engineering problems at the request of other Government organizations. For obvious reasons ship-model work is excluded, and for practical reasons pump and turbine testing is not feasible at the present time. The general study of the theoretical bases underlying hydraulic model studies is an important field of research that has not received sufficient attention. It appears likely that the laboratory will enter this field in the near future. Model tests for specific purposes have been conducted for and with the cooperation of several Government departments. The purposes of such model tests are (1) to check calculations of design, (2) to suggest improvements either to assure better performance or to lower costs without material sacrifice in performance, and (3) to discover and correct undesirable or even dangerous conditions which could not have been foreseen in the design. Lantern slides were shown illustrating representative model tests, and some of the problems encountered in making these studies were discussed. These problems include on the one hand, the construction, operation, and instrumentation of models, and on the other hand, the difficulties and uncertainties arising from the impossibility of obtaining strict similarity of model to prototype. (*Author's abstract.*)

H. E. SAUNDERS, U. S. Navy: *The David W. Taylor Model Basin at Carderock, Md.*—The completion of the buildings for the new ship model testing establishment of the United States Navy at Carderock, Md., just northwest of Washington, has already received considerable publicity in the press. These buildings have a function much different from that of the multitude of new public buildings erected throughout the country in the last decade. Pictorially they are of great interest to the public because of the simplicity

and dignity of their architecture and the use of precast exposed aggregate concrete for the exterior finish. The large building housing the model basins, with its arch roof, is a quarter of a mile long and is the only one of its type in the United States.

The new establishment has been named the David W. Taylor Model Basin in honor of Rear Admiral David W. Taylor, Construction Corps, U. S. Navy (Retired), whose researches in ship propulsion and whose experiments with ship models have made his name renowned throughout the world.

The model testing plant at Carderock includes four separate model basins, each of which is designed to undertake and prosecute to the best advantage a particular kind of ship model research. These four basins will, in addition, provide a plant of vastly increased capacity for undertaking a steadily increasing volume of work. The old model basin at the Washington Navy Yard, built in 1899, is now running sixteen hours a day in an endeavor to keep pace with the requirements of the current naval and merchant ship program. The ship-model basins at Washington are the only ones in America equipped to undertake tests of ship models when they are driven by their own propellers. They perform towing tests and self-propelled tests of this kind for private shipbuilders and naval architects of the United States as well as for the Navy Department and all other Government departments.

To enable the staff to make correct predictions of ship performances to within a few percent, as modern designs require, the new basins at Carderock, embody a number of distinctly novel features. To obtain the desired accuracy for model tests, the carriages that tow the ship models through the basins must run at constant speed on tracks that are straight and level within a few thousandths of an inch.

The walls of the basins upon which these tracks rest are of massive concrete construction, built directly upon bed rock. The track structure is of a new design, using a rail heavier than that employed on any railroad in the world and a rail supporting structure which is much more rigid than that in any other model basin track. As it is expected that at least a year will be required to lay the carriage tracks to the requisite degree of accuracy, it is intended by this means to provide a permanent track structure which will require no further attention for many years to come.

The work of laying the tracks alongside the new model basins is now being undertaken by the staff of the David W. Taylor Model Basin and they hope that by the summer of 1940 the work of ship model testing in the new plant will have begun. (*Author's abstract.*)

The second paper was discussed by Messrs. LIFEROCK and PAWLING.

1157TH MEETING

The 1157th meeting was held in the Cosmos Club Auditorium, Saturday, November 11, 1939, President BRICKWEDDE presiding.

Program: L. V. BERKNER: *Fluctuations in the earth's outer atmosphere during a great magnetic storm.*—The great magnetic disturbance that occurred on April 16, 1938, was one of the largest in recent years. Records of ionospheric changes on the magnetic equator at Huancayo, Peru, are complete during this disturbance. Actual distribution of ion-density at successive quarter-hourly intervals can be represented by parabolic distributions which would produce the observed records using a method recently described by Booker and Seaton.

With advent of the storm, just after midnight, maximum electron density of the F-region (above 250 km) fell in the first hour by three orders of magnitude and essentially to zero, with the disturbance progressing downward through the ionosphere. Then appeared an intensely ionized absorbing region at 85 km (near where maximum conductivity per electron is experienced) which is shown to have covered a substantial portion of the earth's surface. The disturbance then progressed rapidly upward with the height of F-region apparently rising at about 8 km per second first with increasing and then decreasing ion-density until there remained a maximum density of only 5,000 electrons per cc in the neighborhood of 1,000 km. Recovery came with daylight.

A number of interesting problems are raised in view of the restrictive influence of the earth's magnetic field on motions of charged particles at the magnetic equator. Possibly the ionosphere above Huancayo might be imagined to explode toward the polar regions during the disturbance. Mechanism of entrance of the disturbing influence from the sun which produced the effect offers room for speculation. (*Author's abstract.*)

ELLIS A. JOHNSON: *Scattering of light from a modulated searchlight beam at high altitudes.*—The measurement of the light scattered by the atmosphere from an intense searchlight beam up to heights of 34 km was described. The method makes it possible to determine the temperature and pressure with height above the earth's surface and to make determinations of some of the atmospheric constituents. The experimental procedure consists in directing an intense searchlight beam nearly vertical and modulating it at 10 cycles per second with Venetian blind shutters. A receiver, consisting of a large mirror with a photoelectric cell at its focus, is placed about 6 km away. The beam can be scanned by tilting the receiver and the height at any particular angle calculated from the geometry. The sensitivity is limited by the background statistical fluctuation of shot-effect due to photocell current caused by light from the night sky. Measurements above a low haze bank agreed with the atmosphere given by Humphreys up to 34 km. With 60-inch mirrors at the receiver and transmitter, it is calculated that heights of 80 km could be reached, and problems such as the distribution of ozone, water vapor, turbulence, winds, dust, fluorescence, etc., could be studied. (*Author's abstract.*)

The first paper was discussed by Messrs. SEEGER, GOLDBERG, BITTENGER, MOHLER, BRICKWEDDE, S. S. HURLEY, HOWE, MCNISH, and SMITH; the second paper by Mr. BRICKWEDDE.

J. PAWLING presented an informal communication, which was a report of progress on *The new general catalog of Albany.*

1158TH MEETING

The 1158th meeting was held in the Cosmos Club Auditorium, Saturday, November 25, 1939, President BRICKWEDDE presiding.

Program: J. C. HUBBARD, Johns Hopkins University: *Ultrasonics and the ratio of specific heats of gases.*—Among the indirect methods of studying the specific heats of gases, those involving measurements of sound velocity have been considered most ideal. However, until the advent of ultrasonics, values obtained by acoustic methods have been disappointing, in spite of a vast amount of empirical and theoretical work on corrections entailed by the confinement of sound waves within a chamber necessarily of dimensions of the same order of magnitude as the wavelength. Ultrasonics provides wave lengths measured in millimeters or less, and experiments with them are com-

parable to experiments with ordinary sound waves in chambers so large as to eliminate the boundary corrections. The way is thus opened to a study of various gases; moreover these need be used only in small amounts. The results are of a highly satisfactory precision and yield satisfactory values of specific heats except insofar as they are influenced by the dynamic character of sound waves. In many cases it is found that there is a lag in the adjustment of certain energy states of the molecule. This effect was responsible for ultrasonic dispersion found in CO_2 in 1925 by G. W. Pierce and accounted for theoretically in 1928 by Herzfeld and Rice. Ultrasonic methods have now been developed so that precise acoustic data on specific heats may be secured over a very great range of temperatures and pressures. The character of the results permits the detection of those regions of pressure or frequency in which energy lags are present, and are thus useful in determining lifetimes of energy states. Examples were shown. (*Author's abstract.*)

FRANCIS E. FOX, Catholic University of America: *Supersonics in liquids.*—For the production of ultrasonic waves in liquids the source is usually a magnetostrictive rod or piezo-electric quartz plate with its vibration electrically maintained and coupled by direct contact with the liquid. The investigation of the waves, and through them of acoustic properties of the liquid, may be carried out by electrical, mechanical, or optical effects produced by the waves.

(1) The reaction upon the driving electrical circuits produced by waves reflected back to the source, as in the acoustic interferometer, may be expressed as functions of the reflector distance and the half-wavelength in the medium, the absorption factor, and the coefficient of reflection. (2) The steady radiation pressure exerted on an obstacle in the sound field offers a direct means of investigating the intensity. (3) The variations in the index of optical refraction that are produced by the sound wave have been the basis of many optical methods. (*a*) in the Sears-Debye method one uses the sound beam as an optical grating. Progressive or stationary waves may be used. (*b*) With Schlieren methods, of which there are many variations one renders the stationary sound fields visible with constant illumination, or employs stroboscopic light to investigate progressive waves. (*c*) The diffraction-interference methods enable one to 'see' the sound field in the liquid.

The choice of a method depends of course on the problem to be investigated. Methods that permit accurate determination of wavelength may yield little information about intensity or absorption. It may be possible to extend the range of frequency in which some one method is applicable by combining that method with a different one, e.g., the acoustic interferometer with an optical indicator or resonance for very short wavelengths.

The demonstration included the acoustic interferometer, radiation pressure, and several optical effects. (*Author's abstract.*)

The first paper was discussed by Messrs. H. L. CURTIS, HERZFELD, and BRICKWEDDE; the second one by Messrs. BRICKWEDDE, LEWIS, and others.

1159TH MEETING

The 1159th meeting, constituting the 69th annual meeting, was held in the Cosmos Club Auditorium, Saturday, December 9, 1939, President BRICKWEDDE presiding.

The treasurer reported that the income from dues, interest on investments, and sale of reprints was $1,392.94 and that the expenditures exclusive of investments was $1,342.46, leaving a net surplus of $50.48 on ordinary expenses. The ordinary expenditures were at the rate of $4.18 per member.

The secretaries' joint report showed an active membership as of December 1, 1939, of 321, of whom the following were elected during the year: JOHN BEEK, JR., PAUL BRADT, BRICE A. BROOKS, L. O. COLBERT, RICHARD M. FRAPS, CHAS. K. GREEN, RALPH F. HAUPT, ALBERT J. HOSKINSON, HENRI JORDAN, J. W. JOYCE, THOBURN C. LYON, HAROLD W. MURRAY, F. W. REICHELDERFER, C.-G. ROSSBY, W. H. SEAQUIST, DOUGLAS R. TATE, W. A. WILDHACK, and WALTER J. YOUNG. The following were elected in 1938 and qualified in 1939: L. LEON SHERESHEFSKY and H. M. O'BRYAN.

The following death was reported: JAMES H. GORE.

The following officers were declared elected for the year 1940:

President, R. E. GIBSON; *Vice-Presidents*, H. E. MCCOMB and W. G. BROMBACHER; *Corresponding Secretary*, H. F. STIMSON; *Treasurer*, W. E. DEMING; *Members-at-Large of the General Committee*, L. V. BERKNER and R. W. CURTIS.

Program: G. GAMOW: *Uncertainties in atomic and common life.*—In classical physics, the notions of the trajectory, position, and velocity of a moving object were always considered as given *a priori* and self-evident. However, the discovery of the quantum-phenomena leads to a conclusion that these seemingly fundamental notions represent actually only very good approximations to quite different and rather involved basic principles of a correct system of mechanics.

Analyzing the method by which an idea of trajectory, for example, could be constructed, we find that this cannot be done if the physical action can be delivered only in the form of certain finite portions or quanta. This criticism leads to fundamental uncertainty in the description of physical phenomena, expressed in the so-called Heisenberg's uncertainty relations between the coordinates and mechanical momenta of moving particles. It can be shown that the product of the uncertainties of these two quantities is equal to the basic quantum constant, so that if the position is known very accurately, the momentum is not, and vice versa.

Analogous relation exists between the energy and time, which, according to the theory of relativity, represents the fourth pair of data describing the event in the four-dimensional time-space. The possible methods for simultaneous measurement of energy and time have been discussed by N. Bohr who has shown that such measurements necessitate taking into account the effects of general relativity. Making use of Einstein's "red-shift-formula," Bohr proved that the uncertainty relation between energy and time must hold in any such measurement.

It is usually believed that owing to extremely small value of the quantum-constant, uncertainty phenomena can be of importance only in the atomic world. It is, however, not so. If, for example, we fix a steel ball 1 inch in diameter rigidly on the table and drop another ball of the same size from the point several feet above the fixed ball, classical mechanics will tell us that our ball will jump up and down until the energy will be dissipated by friction. According to quantum-mechanics, however, the existing uncertainty of the position and momentum of the ball at the moment it is dropped, will cause a quite appreciable deviation and will make the ball drop aside after only a few jumps. Unfortunately no technically produced steel is homogeneous enough to permit such experimentation.

We can imagine, however, some crazy worlds in which the quantum-constant is so large that the uncertainty relations could be observed microscopically. One fellow, called Mr. Tompkins, used to dream about such worlds and had a lot of very unusual experiences in them. Not only was he unable

to play a good billiard game with "spreading-out" quantum balls, but also his car ran out of the garage leaving through the wall just as an α particle from the atomic nucleus. Going to hunt tigers, he was quite scared to see a tremendous number of tigers jumping on his elephant simultaneously from all sides. He explained, however, that there was only one tiger in the first quantum state around the elephant, and the tiger was soon shot by a quantum bullet. Mr. Tompkins awoke after that event, but forever after remembered what the uncertainty-relations actually are. (*Author's abstract.*)

This paper was discussed by Messrs. O'BRYAN and BRICKWEDDE.

1160TH MEETING

The 1160th meeting was held in the Cosmos Club Auditorium, Saturday, January 6, 1940, President GIBSON presiding.

The Retiring President, F. G. BRICKWEDDE, gave an address entitled *Some complexities of the simple element hydrogen.* It is expected that this address will be published in this JOURNAL.

1161ST MEETING

The 1161st meeting was held in the Cosmos Club Auditorium, Saturday, January 20, 1940, President GIBSON presiding.

Program: F. S. BRACKETT: *Spectroscopic methods and their importance in biological research.*—When radiation produces a measurable change, be it physical, chemical, or biological, the plot of wavelength dependence of the measured change may be termed an "action spectrum." In biophysics action spectra are fully as important as emission and absorption spectra. Familiar examples: In physics, the wavelength dependence of photocell sensitivity; in chemistry, the photochemical yield as a function of wavelength; and in biology, the visibility curve of the eye.

The photochemical problem is simpler than the biophysical, since the absorption spectrum of the absorbing molecules may be measured and the concentrations of the components of the system varied in order to determine the kinetics of the system. Here the purpose of the action spectrum is to establish the photochemical threshold and the quantum efficiency. In biophysics, even the absorbing molecule may be unknown. The purpose of the action spectrum may therefore be to determine the effective absorption spectrum and the efficiency or number of quanta required to produce the effect. A common form of biophysical action spectrum is the wavelength plot of the reciprocal of the incident energy required to produce an equal biological change. Typical example—the lethal action of radiation on microorganisms. Assuming Beer's law a general expression is deduced which leads to simple interpretation in two important cases. One, where the population of microorganisms in suspension is small, that is, less than ten percent of the beam absorbed. Here it is shown that the action spectrum yields the wavelength dependence of the product of efficiency and absorption coefficient per organism. The second case is where the number of organisms in suspension is large, so that practically all energy is absorbed. Here the action spectrum yields directly the efficiency or the reciprocal of the number of quanta required to kill the organism.

The requirements on spectrographic equipment for obtaining action spectra are fundamentally different from those to obtain emission or absorption spectra. In general an output of great radiant power is necessary in order to produce a measurable change in a reasonable length of time, but high intensity is not necessary. High purity, that is, freedom from scattered radia-

tion is required though high resolving power is not. This leads to instruments with a large linear aperture but not necessarily large relative aperture; high dispersion but low resolving power. For this purpose, large quartz prisms are ideal in the ultraviolet, the number of prisms being as great as is compatible with maintenance of high transmission. Gratings are preferable in the visible. Slit widths may be wide, but a double monochromator to eliminate scattered radiation is often necessary. (*Author's abstract.*)

P. A. COLE, National Institute of Health: *Determination of cell structure by means of the ultraviolet microscope.*—A brief summary of the historical development of the ultraviolet microscope was given. An eventual goal of all previous workers has seemed to be to attain ultraviolet absorption spectra of microscopic objects. The difficulties encountered in attaining this goal were discussed. Preliminary photographs were shown taken at various ultraviolet wavelengths and a method was described by which the absorption spectrum of a portion of a microscopic organism could be determined. (*Author's abstract.*)

The first paper was discussed by Mr. O'BRYAN; the second one by Messrs. GIBSON, BRACKETT, BRIGGS, TELLER, HUMPHREYS, H. L. CURTIS, F. COE, and others.

1162D MEETING

The 1162d meeting was held in the Cosmos Club Auditorium, Saturday, February 3, 1940, President GIBSON presiding.

Program: P. A. SMITH: *Exploring the continental shelves and slopes.*—Knowledge of the topography of the sea floor has grown rapidly during the past decade, largely through the development of echo-sounding. Owing to the accompanying need for more complete nautical charts, several of the maritime nations have extended hydrographic surveys seaward from their shores; and due to this seaward extension of the surveys a whole new physiographic realm is being opened to students of earth science. The perfection and use of offshore position finding methods and echo sounding by the U. S. Coast and Geodetic Survey has added many thousands of square miles of surveys of the continental shelves and slopes of United States and waters under their jurisdiction. The discovery of the stream-erosion type of topography on the seaward faces of the continental shelves under hundreds of fathoms of water has raised questions that seriously affect a number of cherished geological theories. While topographic characteristics of numerous submarine canyons are clearly and unmistakably those commonly observed in valleys eroded by running water above the sea, many geologists have felt that the simple explanation of a lowered sea or rising land in the order of 10,000 feet and back in late Tertiary or Pleistocene time is untenable in the face of apparently well-established theories. A number of hypotheses have been advanced in the attempt to explain these features by some process that may harmonize with other geologic evidence, but the origin of submarine canyons is still controversial.

Through a number of contributors, including Dr. H. S. Stetson of the Woods Hole Oceanographic Institution, Dr. Maurice Ewing of Lehigh University, and collaborators, and Dr. C. S. Piggot of the Geophysical Laboratory, Carnegie Institution, our knowledge of the materials and underlying strata of the sea floor is being expanded. In all this work the Geological Society of America has been especially interested, and has contributed greatly to the growth of knowledge in this field of science through grants to various investigators.

Automatically recorded profiles of submarine topography of the Atlantic Continental Slope show decidedly V-shaped cross sections, in the extreme heads of the canyons as well as in depths of 6,000 feet and over. Due to certain limitations of echo sounding it is sometimes impossible to record the bottom of steep, narrow ravines in deep water, or to record true slopes in very rugged topography. Graphic records of echo sounding always give a more complete picture of the profile than visual indicators and in many instances reveal phenomena that might otherwise be missed, such as the great sand waves found south of Nantucket Island during the summer of 1939 by the Coast and Geodetic Survey Ship *Oceanographer*.

The abrupt change from the topography of the shelf which is plainly marine made in character, to that of the slope which shows no indications of marine erosion, but is plainly that commonly attributed to stream erosion is one of the most remarkable of the many interesting facts demonstrated by the new surveys. The cooperation of the Geological Society of America through the late Dr. A. C. Veatch and the Coast and Geodetic Survey has resulted in the publication of these new surveys in the form of special charts for use by various investigators. (*Author's abstract.*)

T. C. LYON, U. S. Coast and Geodetic Survey: *Methods of air navigation and aeronautical charts.*—Air transportation is still making rapid strides, and the distribution of aeronautical charts by the Coast and Geodetic Survey during the past year exceeded the distribution of nautical charts.

The basic methods of marine navigation are also the basic methods of air navigation, although new instruments and stream-lined technique are required for the higher speeds of aircraft.

Aeronautical charts are comparable to nautical charts. They differ from topographic maps in their emphasis upon landmarks, in the degree of accuracy required, and in the necessity for frequent revisions.

Three standard series of aeronautical charts are now being published by the Survey: 87 sectional charts, scale 1:500,000; 17 regional charts at 1:1,000,000; and 6 direction finding charts at 1:2,000,000—all on the Lambert conformal conic projection. These are designed to meet the needs of aircraft of widely different speeds and methods of navigation.

Aeranautical charts are compiled from the best available data, and checked from the air before distribution. For the future, air navigation will be at new altitudes, with new methods, new instruments, and possibly new charts, in prospect.

Specimens of the standard charts, and also of several experimental charts, were on display. (*Author's abstract.*)

The first paper was discussed by Messrs. EATON, PAWLING, and HUMPHREYS.

1163D MEETING

The 1163d meeting was held in the Cosmos Club Auditorium, Saturday, February 17, 1940, President GIBSON presiding.

Program: H. R. MORGAN, U. S. Naval Observatory: *The motions of the earth.*—Observations of the sun, moon, and planets in the past 300 years show rather large and irregular deviations from their gravitational orbits. These are attributed to fluctuations in the rate of rotation of the earth giving a variable time amounting to as much as 60 seconds of time in a century as compared with a perfectly uniform time.

To determine the motions of the planets over long periods of time it is necessary to have a uniform time unit. The new tables of the moon are so

accurate they may be used for this. In an investigation of the motion of the planet Mercury, now being carried on at the Naval Observatory, the observed deviations of the moon from its gravitational orbit are used as the corrections to variable earth time to reduce it to uniform or Newtonian time. (*Author's abstract.*)

C. B. WATTS: *A traveling-wire micrometer with photographic registration.*—The 6-inch transit circle of the U. S. Naval Observatory has been equipped with a photographic register for use with the traveling-wire micrometer. The usual method of recording on a chronograph the signals originated by a contact device on the micrometer has been discarded. It is replaced by a system in which a portion of the graduated head of the screw is photographed periodically on recording paper while a transit is being observed. The exposures are initiated by the clock and no chronograph is required. The result is equivalent to that yielded by the older method; there are, however, several advantages in the new system. One of these is the fact that the position of the traveling wire is recorded at the same time intervals for all declinations. These intervals are sufficiently great to insure the independence of successive recordings; closely spaced signals for an equatorial object and excessively long intervals for a circumpolar star are both avoided. The new device also serves as an efficient recorder of pointings made on the collimators, meridian marks, and reflected nadir images. When used for this purpose the exposures are initiated by the observer. (*Author's abstract.*)

The first paper was discussed by Messrs. MEGGERS and WATTS; the second by H. L. CURTIS.

F. G. BRICKWEDDE gave an informal communication on a new temperature scale that has been proposed. He showed by a quotation from a paper by J. P. Joule and William Thomson entitled *On the thermal effect of fluids in motion*, which appeared in Phil. Trans. **144**: 32 (1854), that the idea was original with them. This was discussed by Messrs. GIBSON and TUCKERMAN.

1164TH MEETING

The 1164th meeting was held in the Cosmos Club Auditorium, Saturday, March 2, 1940, President GIBSON presiding.

Program: A. H. PFUND, Johns Hopkins University: *A partial analysis of gaseous mixtures without the use of a spectroscope.*—This procedure is based on the fact that certain gases and vapors such as CO_2, H_2O, CH_4, etc. have absorption bands in characteristic wave-length regions in the infrared spectrum. The apparatus consists of an incandescent solid whose radiations pass through an initially evacuated absorption-cell and then enter a detector containing a gas such as CO_2. Some of this radiation will be absorbed and transformed into heat, thus raising the temperature of the gas and affecting thermo-junctions not in the direct path of the radiation. Upon admitting air containing CO_2 into the absorption-cell, this CO_2 prematurely removes or weakens those radiations which, previously, had heated the CO_2 in the detector. As a result, the temperature of the gas in the detector drops.

Applications of this procedure to ventilation, fermentation, and respiration were discussed. (*Author's abstract.*)

A. G. MCNISH: *The geomagnetic field and its variations.*—The general magnetic field of the earth may be represented to within the reliability of the observations by a dipole near the center (moment 8×10^{25} cgs units), giving rise to about 80 percent of the field, and 14 secondary radially directed dipoles (average moment 0.1×10^{25} cgs units) located at specified positions

midway between the surface of the earth and its center, giving rise to the remainder or residual field.

Secular change can be represented by the yearly addition of 13 dipoles of equal strength (moment 1.4×10^{22} cgs units) at the same depth as the dipoles of the residual field. Continuance of secular change at the present rate for one hundred years would thus build up a new residual field.

Interpretation of this model leads to the beliefs that (1) at least a considerable portion of the earth's magnetism (the residual field) originates at a lesser depth than the central core revealed by seismological evidence, and (2) secular change involves this residual field and therefore is due to changes taking place between the surface of the earth and the surface of the central core. (*Author's abstract.*)

The first paper was discussed by Messrs. GIBSON, MAXWELL, BRICKWEDDE, KARRER, MUELLER, MCNISH, HUMPHREYS, and ASTIN; the second one by Messrs. GIBSON, SEEGER, TELLER, MCCOMB, SMITH, BRICKWEDDE, and HOWE.

1165TH MEETING

The 1165th meeting was held at the Cosmos Club Auditorium, Saturday, March 16, 1940, President GIBSON presiding.

The Tenth Joseph Henry Lecture entitled *Differences in physical properties of isotopes* was delivered by Prof. HAROLD C. UREY, of Columbia University. This lecture has been published in this JOURNAL **30**: 277–294, 1940.

1166TH MEETING

The 1166th meeting was held in the Cosmos Club Auditorium, Saturday, March 30, 1940, President GIBSON presiding.

Program: R. M. ZABEL, Hygrade Sylvania Corporation: *Fundamentals of fluorescence.*—Since Edison's invention of the incandescent lamp in 1879, incandescent lamp efficiencies have increased from slightly over 1 lumen per watt to 14 lumens per watt for a standard 60 watt tungsten lamp. The introduction of the fluorescent lamp has increased this efficiency to approximately 42 lumens per watt (including lamp wattage and auxiliary loss).

The visible light in a fluorescent lamp is generated by the passage of a discharge through a mixture of argon gas and mercury vapor, the discharge being operated under such conditions that as high a percentage as possible of the radiation generated is in the resonance line of mercury (2537 Å). This ultraviolet radiation is absorbed by the fluorescent material on the inside of the lamp and re-radiated as visible light of a wavelength depending upon the type of fluorescent material used.

The effect of small quantities of foreign materials upon the fluorescent and phosphorescent characteristics of a silicate or tungstate, such as is most commonly used in fluorescent lamps, is very marked. For example, the introduction of 1 percent manganese in zinc silicate greatly increases the fluorescent output and moves the maximum of the output curve from approximately 4,150 Å to 5,230 Å. On the other hand, the introduction of iron, copper, or nickel greatly decreases the fluorescent output. This effect is presumably due to the introduction of additional energy levels in the fluorescent material due to the replacement of the normal metallic constituents of the crystal by the foreign metallic elements. In some cases these additional energy levels are properly placed to radiate light in the visible region. In other cases, they may be so placed as to re-radiate the light outside the visible, generally in the infrared. This, of course, wastes the energy.

Phosphorescence differs from fluorescence in that a time lag exists before the light output of the phosphor builds up to a maximum and also a lag exists in the decline of the light output to zero after the starting or stopping of the exciting radiation. Many fluorescent materials exhibit both fluorescence and phosphorescence. Phosphorescence in the type of materials under consideration is ascribed to the presence of potential traps which hold appreciable quantities of electrons which escape slowly through the barrier of the trap before returning to their normal place in the crystal structure and emitting the radiation normally coincident with this energy interchange.

Various fluorescent materials are mixed to obtain the color desired in a finished fluorescent lamp.

The quantum efficiency of the best fluorescent material found to date is approximately 70 percent. (*Author's abstract.*)

W. P. LOWELL, JR., Hygrade Sylvania Corporation: *Practical application of fluorescent lighting.*—To use fluorescence in practical lighting it is necessary to combine a source of ultraviolet and the proper phosphor in a convenient form, and to devise means of operating this lamp on the 115-volt 60-cycle circuits generally available in this country. The lamps which have been developed are long tubes having electrodes at both ends, powdered phosphor on the inner surface of the tube, and a filling of mercury vapor and rare gas at low pressure.

The electrical control circuit consists of inductive ballast in series with the lamp, to control the current, and an automatic switch to aid in starting the lamp. This switch provides for preheating of the cathodes, then applies sufficient voltage across the tube to insure starting the arc. Several types of starting switches were demonstrated, including Manual, Magnetic, Thermal, "Glow Tube," and High Resistance Thermal.

The power factor of this lamp and inductive ballast being inherently low (and lagging) it is our practice to ballast alternate lamps with a combination of capacitance and inductance, thus operating one lamp with leading current, and the resultant power factor of each pair of lamps very near to unity.

Practical lighting units, each one complete with lamps, ballasts, starters and all necessary reflectors and glass diffusers were demonstrated, including the illumination of one-half the lecture hall with two of the "Miralume" units. Lantern slides were shown of many actual installations of fluorescent lighting.

In conclusion, the effect of Daylight Fluorescent color was demonstrated on flowers and many other objects. The ordinary tungsten filament incandescent lamp is, of course, far more yellow and red than natural daylight, while the Daylight Fluorescent Lamp is very close to actual average daylight (color temperature 6,500° K.). Blue flowers and blue cloth are particularly striking when their true color under Daylight Fluorescent is compared to identical samples under an incandescent source. (*Author's abstract.*)

1167TH MEETING

The 1167th meeting was held in the Cosmos Club Auditorium, Saturday, April 13, 1940, Vice-President MCCOMB presiding.

Program: L. MARTON, R. C. A. Manufacturing Co.: *Electron microscopy.*—The discovery of the optical behavior of electron beams led to the development of a new branch of science: "Electron microscopy." It is based on the analogous use of light optical elements in a compound light microscope and electron optical elements in an electron microscope; and on the highly increased resolving power due to the much shorter wavelength of electrons.

On considerations of wavelength alone, an enormous increase in resolving power should be obtainable. However, this is limited by a number of factors given, chief among them being the optical aberrations, which were discussed in detail and numerically evaluated. It was concluded that at the present state of development of electron microscopy, resolving powers of the order of 10 Å should be obtainable.

After a discussion of constructional details of electron microscopes, a series of micrographs taken by the electron microscope was shown, and the results discussed. It was pointed out that the main applications of the electron microscope at the present time are in bacteriology, virus research, and in the wide field of colloidal research, including not only industrial colloids, but also all the building stones of living matter. (*Author's abstract.*)

The paper was discussed by Messrs. SMITH, HUMPHREYS, ROLLER, COE, MAHAN, READING, BEEK, FARNO, and others.

1168TH MEETING

The 1168th meeting was held in the Cosmos Club Auditorium, Saturday, May 11, 1940, President GIBSON presiding.

Program: J. H. SWARTZ, U. S. Geological Survey: *Resistivity studies of some geological problems.*—In El Paso, Texas, salt water was found to be encroaching upon a well from which a considerable portion of the city's water supply was at that time being drawn. Resistivity measurements were successful in determining the area underlain by salt water and in delineating the boundary between fresh and saline water areas. Salt water predicted for a city well at Clint, Texas, was encountered as predicted when the well was drilled despite the adverse prediction.

In the Hawaiian Islands large amounts of water are developed from thin basal lenses of fresh water floating on the salt water permeating the various islands. It was found possible by resistivity measurements to tell the thickness of such basal fresh water lenses and to determine quite accurately the elevation of the basal water table. Five test checks so far obtained at shafts, drill holes, and wells, have shown an average difference of 0.56 feet between predicted and observed water table elevations.

Studies of perched water horizons are now being made on the island of Maui. While still in an early stage due to the research character of the problem and the stratigraphic complexity involved, encouraging results have been obtained. (*Author's abstract.*)

F. W. LEE, U. S. Geological Survey: *Some problems in geophysics.*—As the science of geophysics has grown, especially in its application to prospecting, there has been a marked evolution in design and use of geophysical apparatus. During this evolution many traditional features of instruments have been improved whereas others have become obsolete. In the light of this progress it is very interesting to examine the many stages of development that scientific prospecting has undergone and is undergoing. Old dousing paraphernalia have been replaced by the magnetic dip needle, which in turn has been largely replaced by the more accurate and much more sensitive magnetic variometer. Magnetic interpretations have made a decided advance by the introduction of magnetic models and magnetic scales. Marked advances have also been made (by the sister methods) in electrical, seismic, and gravitational fields, and scientific prospecting is entering into a new era in which its application will, doubtless, be greatly broadened. In all of these branches of geophysical prospecting there are three distinct divisions which must be closely intercoordinated for securing the optimum results.

First, there is the instrumentation or the design and construction of precision field instruments. Experience in the oil industry shows how much advance can be made in instrument technique if the scientific results are coupled with the prospects of high economic returns. Second, there is the broad research associated with the many types of geologic bodies which commonly differ from territory to territory and also have many modifying controls and factors. Third, there is the theoretical principle involving the application of the magnetic, electric, gravitational, and seismic deformation fields to geologic and engineering problems. The analyses of physical field measurements in these fields often involve very complicated procedure. (*Author's abstract.*)

1169TH MEETING

The 1169th meeting was held in the Cosmos Club Auditorium, Saturday, May 25, 1940, Vice-President BROMBACHER presiding.

Program: JOHN P. HAGEN, Naval Research Laboratory: *Beam power tubes as ultra-high radio frequency generators.*—The increasing use of the lower radio frequencies by the existing commercial services has forced new services into the ultra-high frequency range. There are many features in the behavior of ultra-high frequency circuits and waves which invite their use even though a condition of saturation had not been reached in the lower frequencies.

The advent of tubes of the beam type, such as the Inductive Output Tube, the Klystron and the Velocity Modulated Tube, has made the use of the ultra-high frequencies practicable. The essential features in the action of these tubes are: the production of a cylindrical beam of electrons; the acceleration of the beam by means of a high voltage anode which collects little current; the amplitude modulation of the beam by conventional grid action as in the Inductive Output Tube, or the velocity modulation of the beam as in the latter two types; the subsequent induction of the power from the beam to a plate tank circuit which collects little or no direct current. This tank circuit is usually some form of resonant transmission line; and the eventual collection of the beam, which has given up its radio frequency power, by means of a collecting anode at lower direct current potential. (*Author's abstract.*)

OSCAR NORGORDEN: *Propagation characteristics of ultra-high radio frequencies.*—One of the important links in a radio communication system is the propagation of the radio waves between the transmitting and receiving antennas. The electric field strength is proportional to the square root of the power and must exceed some definite value if to be useful for communication purposes.

At the ultra-high frequencies, frequencies above 100 megacycles, the transmitting and receiving antennas are elevated several wavelengths above the surface of the earth. For distances less than the optical range or line of sight the field strength E at the receiving antenna is

$$E = E_1 + E_2$$

where E_1 and E_2 are the electric fields at the receiving antenna due to the direct and reflected rays respectively. Thus an interference pattern should be observed for the variation of the field strength with distance. Measurements show that this interference pattern does exist and is in agreement with the theory. For distances greater than the optical range the field strength decreases exponentially with the distance. Thus the maximum useful communication distance for the ultra-high frequencies is nearly independent of

the power and is approximately equal to the optical range. (*Author's abstract.*)

The first paper was discussed by Messrs. RAMBERG, SMITH, MAXWELL, and BLAIR; the second by Messrs. MAXWELL, BROMBACHER, BRICKWEDDE, SEEGER, BLAIR, and MOHLER.

RAYMOND J. SEEGER, *Recording Secretary.*

Obituary

CYRUS ADLER, president of Dropsie College for Hebrew and Cognate Learning, died at his home in Philadelphia on April 7, 1940. He was born in Van Buren, Ark., on September 13, 1863. He received the A.B. degree from the University of Pennsylvania in 1883, the A.M. in 1886. From Johns Hopkins University he received his Ph.D. in 1887. Hebrew Union College gave him his L.H.D. in 1925; University of Pennsylvania, his Litt.D. in 1930. He was in turn Fellow, Instructor, and Associate in Semitic languages at Johns Hopkins from 1884 to 1893. At the Smithsonian Institution in Washington he served successively as librarian, 1892–1905; as assistant secretary, 1905–1908; and as assistant curator and curator of historic archeology and historic religions, 1888 to 1908. He was elected president of Dropsie College in 1908; acting president of Jewish Theological Seminary of America in 1916, president in 1924. Throughout his life he was a tireless worker in the field of education and in recent years served as a member of the board of education in Philadelphia; as president of the board of trustees Philadelphia Free Library; and as a member of the board of Gratz College. He was a delegate to the conference on an International Catalogue of Scientific Literature in 1908 and since served as member of the international committee. Widely known as an educator, writer, and philosopher, Dr. Adler was also one of the recognized leaders of the Jews in America.

The bibliography appearing in "Lectures, Selected Papers, Addresses" by Cyrus Adler, published by his friends and colleagues on the occasion of his 70th birthday, includes nearly 600 titles. In addition, there is a list of 17 publications "edited by Dr. Adler, or issued under his supervision." He was editor of the Jefferson Bible; of the American Jewish Year Book, 1899–1906; of the Jewish Quarterly, since 1910; and one of the editors of the Jewish Encyclopedia. His writings included Oriental, archeological, and philological subjects; he was an authority on comparative religion and American Jewish history. Among other organizations, Dr. Adler was a member of the Washington Academy of Sciences, a member and past officer of the American Philosophical Society; the American Jewish Historical Society; and the American Oriental Society. He was a member of the Cosmos Club in Washington and of the Oriental and University Clubs in Philadelphia.